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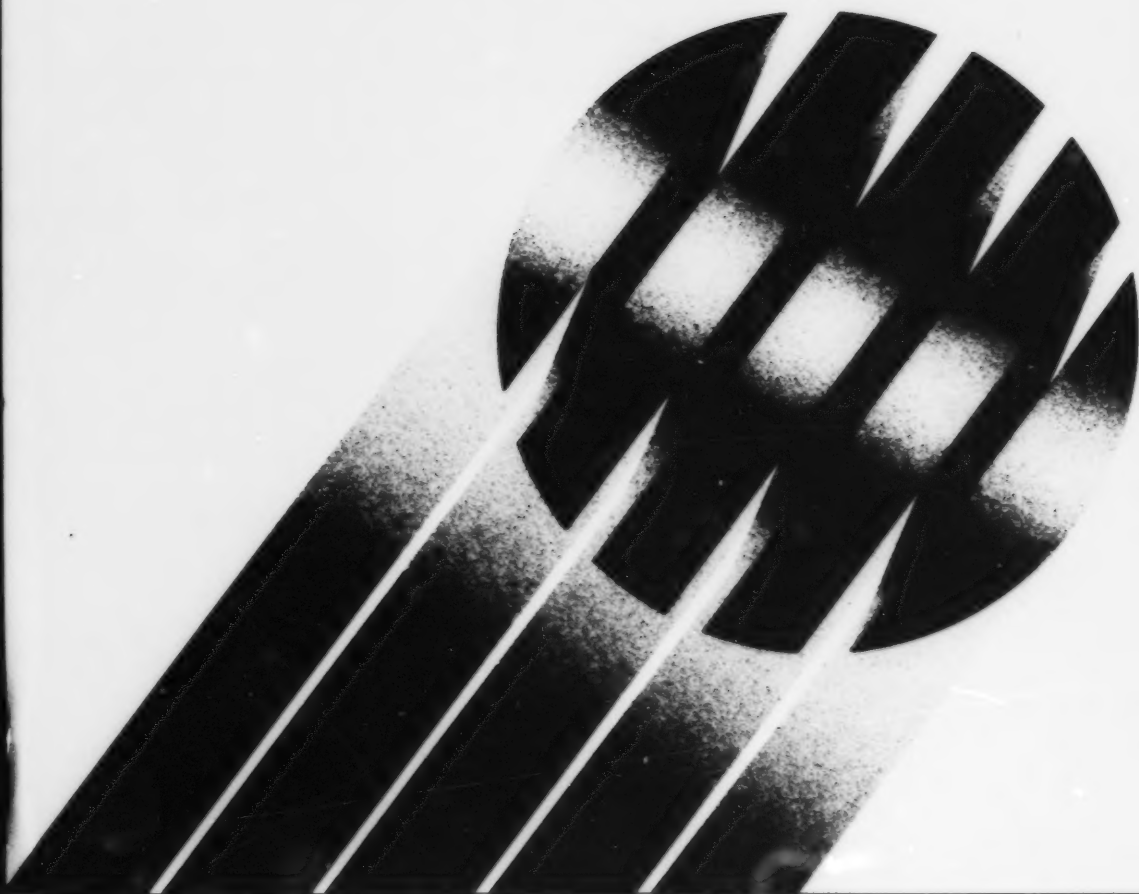
Canada Centre for
Mineral and Energy
Technology

Centre canadien de la
technologie des
minéraux et de l'énergie

SUMMARY REPORT NO. 11: NEPHELINE SYENITE AND FELDSPAR

R.K. COLLINGS AND P.R.A. ANDREWS
Mineral Processing Laboratory

MINERAL SCIENCES LABORATORIES



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l'énergie (CANMET).



SUMMARY REPORT NO. 11: NEPHELINE SYENITE AND FELDSPAR

by

R.K. Collings* and P.R.A. Andrews****Abstract**

Nepheline syenite and feldspar are basic aluminum silicates. The main difference between the two minerals is that nepheline syenite contains a greater proportion of alumina (23.5 to 24.2%) than feldspar (18.3 to 19.4%).

Nepheline syenite chiefly occurs in Ontario with some minor deposits in British Columbia. Feldspar occurs in every province of Canada as a constituent in granite pegmatites, but economic deposits are restricted to Nova Scotia, Quebec, Manitoba and British Columbia. There is only one producer of nepheline syenite in Canada, in Ontario, and feldspar is no longer mined.

The main use for nepheline syenite and feldspar is as a source of alumina in glass manufacture; nepheline syenite is generally preferred because of its higher alumina content. The other uses for nepheline syenite are in ceramic whiteware products and glazes, in wall and floor tile compositions, and as a filler/extender in paints, plastics and foam rubber. Potash feldspar is used in the manufacture of high-voltage electrical insulators, and pure-white grades are used as dental porcelain in the manufacture of artificial teeth.

Nepheline syenite and feldspar ore samples have been studied extensively at CANMET and its predecessor, Mines Branch, between 1931 and 1986. A summary of processing data and testwork results is presented in four appendices.

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RAPPORT SOMMAIRE N° 11 - SYÉNITE NÉPHÉLINIQUE ET FELDSPATH

par

R.K. Collings* et P.R.A. Andrews****Résumé**

La syénite néphélinique et le feldspath sont des silicates d'aluminium basiques. Leur principale différence tient au fait que la syénite néphélinique contient plus d'alumine (23,5 - 24,2 %) que de feldspath (18,3 % - 19,4 %).

La syénite néphélinique se rencontre principalement en Ontario; il existe aussi quelques gisements mineurs en Colombie-Britannique. On trouve du feldspath dans des pegmatites granitiques dans toutes les provinces du Canada; la Nouvelle-Écosse, le Québec, le Manitoba et la Colombie-Britannique sont les seules provinces à posséder des gisements rentables. Il n'existe qu'un seul producteur de syénite néphélinique au pays, soit en Ontario; le feldspath n'est plus exploité au Canada.

La syénite néphélinique et le feldspath servent principalement de source d'alumine pour la fabrication du verre; en général, on préfère la syénite néphélinique, car elle est plus riche en alumine. On utilise aussi la syénite néphélinique dans la céramique à pâte blanche et ses glaçures, dans les carreaux pour mur et pour sol et dans les matières de charge/pigments de charge pour les peintures, les plastiques et le caoutchouc mousse. On utilise le feldspath potassique dans la fabrication d'isolateurs électriques à haute tension, et le spath dentaire, une variété de couleur blanc pur, dans la fabrication des dents artificiels.

Entre 1931 et 1986, les échantillons de syénite néphélinique et de feldspath ont fait l'objet de nombreuses études à CANMET, anciennement la Direction des mines. Les données sur le traitement et les résultats d'essais sont résumés dans quatre annexes.

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INTRODUCTION

A CANMET survey of Canadian industrial mineral producers (1) identified a number of problems specific to the industry as well as potential opportunities for further development and expansion. Subsequent discussions with industry and government specialists identified a requirement for information in a number of areas. These areas included mineral deposits, processing, beneficiation studies and new developments, as well as information on product specifications and potential markets for Canadian industrial minerals.

Related information on file at CANMET, and as available from provincial government offices and the private sector, were subsequently compiled in a series of Summary Reports on a number of industrial minerals. The information for each mineral pertains to mineral occurrences, deposits of specific interest, current activities, product uses and specifications, process technology, and summaries of past testwork on specific deposits by CANMET and others. This report, Summary Report No. 11: Nepheline Syenite and Feldspar, is the eleventh in the series. The previous reports are:

- | | |
|--------|-------------------------------------|
| No. 1 | Barite |
| No. 2 | Celestite |
| No. 3 | Fluorite |
| No. 4 | Silica |
| No. 5 | Graphite |
| No. 6 | Mica and Vermiculite |
| No. 7 | Gypsum and Anhydrite |
| No. 8 | Talc and Pyrophyllite |
| No. 9 | Magnesite, Brucite and Dolomite |
| No. 10 | Kyanite, Sillimanite and Andalusite |

NEPHELINE SYENITE

Mineralogy and Geology

Nepheline syenite is a light-coloured, silica-deficient, coarse-to-medium-grained crystalline igneous rock, in which the essential mineral constituents are microcline, orthoclase or albite

feldspars, nepheline, and ferromagnesian minerals, principally hornblende, pyroxene and biotite. Accessory minerals typically include magnetite, ilmenite, calcite, garnet, zircon and corundum. Nepheline, the most common feldspathoid mineral in nepheline syenite, is represented by the structural formula $\text{Na}_3\text{KAl}_4\text{Si}_4\text{O}_{16}$. Nepheline crystallizes in the hexagonal system, has a distinct but imperfect cleavage, a hardness of 5.5 to 6.0 on Mohs' scale, and a specific gravity of 2.5 to 2.7. Nepheline is colourless to white or yellow, but in massive form may be dark green, blue-gray, brown or brick-red.

Principal Occurrences

Although nepheline syenite occurrences are numerous in Canada, deposits are usually limited in area. The chief and only operating deposit is at Blue Mountain, north of Peterborough, Ontario. A number of other potentially commercial deposits occur in other regions of Ontario, and in Quebec and British Columbia. These are described as follows, and are noted in Fig. 1:

Quebec

Gittens (2) describes a nepheline syenite alkaline intrusive complex located in the Gouin Reservoir area, 145 km south of Chibougamau. This oval complex measures 6 by 9 km in area and contains a central, 4.5 by 5.5 km core of nepheline syenite. The core is described as consisting primarily of nephelines and feldspars with up to 15% biotite as the chief impurity, and with only minor magnetite. A satellite, 1.0 by 2.5 km body of nepheline syenite, was noted as occurring 2.4 km to the north of the main intrusive.

Barry and Fumerton (3) noted occurrences of three nepheline syenite bodies 75 km northwest of Shefferville, Quebec, near Goodwood River. The largest of the three is 10 km², the intermediate 6 km², and the smallest 2 km² in area. These bodies are reported to be composed of nepheline, perthite, biotite, clinopyroxene, magnetite and apatite. The core rock is largely nepheline syenite which ranges from 0 to 60% nepheline. Pegmatitic bands

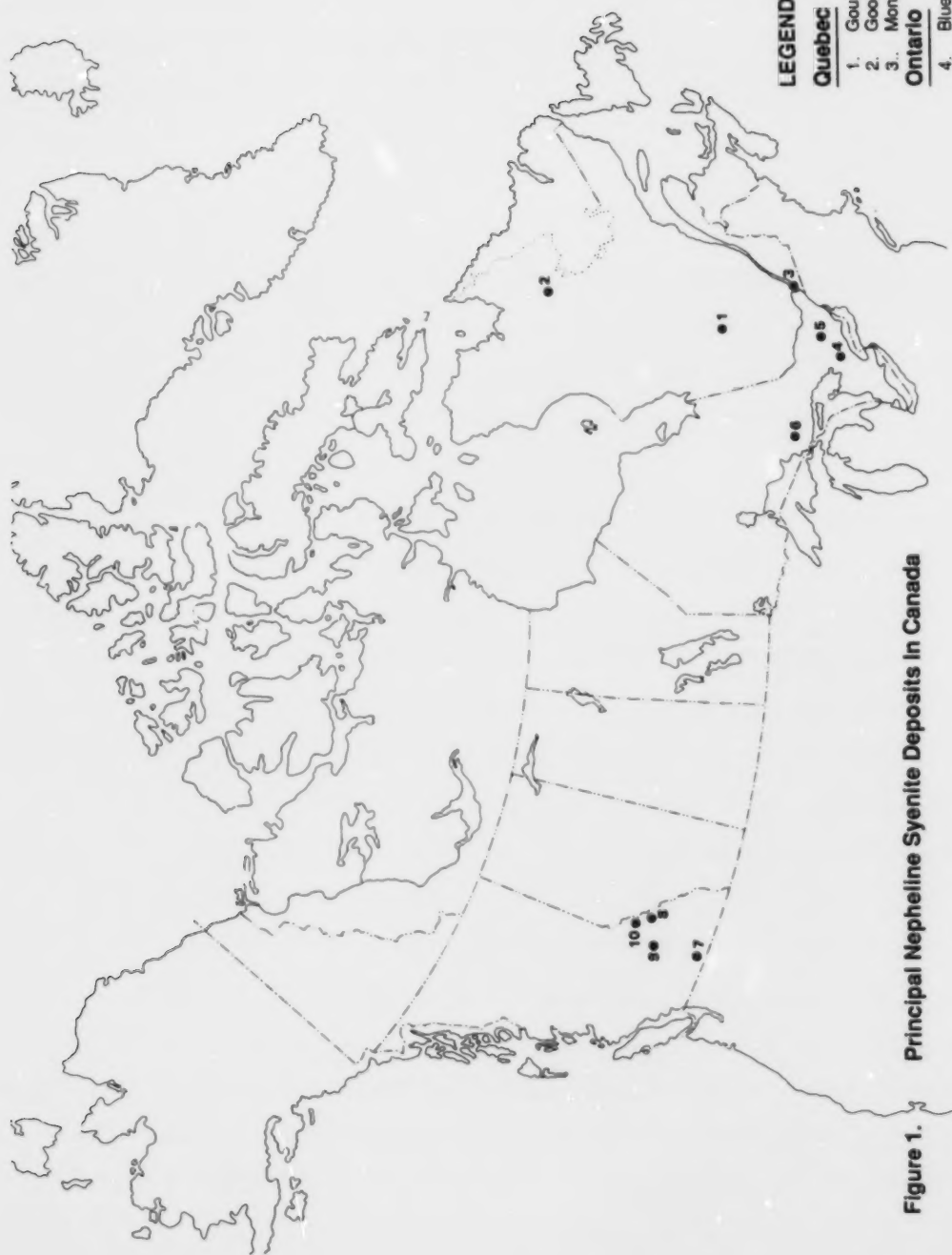


Figure 1. Principal Nepheline Syenite Deposits In Canada

LEGEND

Quebec

1. Gouin Reservoir
2. Goodwood River
3. Mont St. Hilaire, Mount Brome, Mount Royal

Ontario

4. Blue Mountain
5. Dugannon-Monteagle-Carlton
6. Nemegos

British Columbia

7. Kruger Mountain
8. Mount Copeland
9. Barrère
10. Trident Mountain

and lenses of feldspar and accessory biotite and magnetite are widely distributed throughout the nepheline syenite bodies. They are typically less than 10 cm in thickness, although they form up to 50% of the outcrop in places.

Buchanan (4) lists three principal bodies of nepheline syenite in the general vicinity of Montreal: Mont St. Hilaire, Mount Brome and Mount Royal, each containing significant quantities of nepheline syenite.

Ontario

Ontario nepheline syenite occurrences are well described by Hewitt (5) who sub-divides them on the basis of their location in the southern or northern part of the province.

Occurrences in southern Ontario are noted in Peterborough, Haliburton, Hastings and Renfrew Counties, and in the districts of Sudbury and Nipissing. The main deposits are the Blue Mountain deposit in Methuen Township, Peterborough County, and the Dungannon-Monteagle-Carlow area deposits in Hastings County. The Blue Mountain deposit is the largest known deposit in Ontario, and the only deposit currently being mined in Canada. The main deposit rises 60 to 100 m above the surrounding area and is 4 km long by 2.5 km wide. A sill-like arm, up to 0.4 km in width, extends a further 6.5 km in a southwesterly direction from the main deposit. The Blue Mountain deposit is principally composed of 22% nepheline, 54% albite and 22% microcline, with varying but minor quantities of magnetite, biotite, muscovite and garnet. Crude ore from this deposit typically analyses 59% SiO_2 , 23% Al_2O_3 , 10% Na_2O , 4% K_2O and 2% Fe_2O_3 . The Dungannon-Monteagle-Carlow deposits noted by Hewitt are extensive and among the largest in the Haliburton-Bancroft area.

Occurrences in northern Ontario are noted in the districts of Timiskaming, Sudbury, Algoma, Thunder Bay and Rainy River. The chief among these is the Nemegos deposit, in Lackner and McNaught Townships, district of Sudbury. This deposit is contained in a ring-like,

intrusive formation that is about 5 km in diameter. The complex is of variable composition, but typically contains 35 to 40% nepheline with associated alkali feldspars.

At other locations in Ontario, nepheline syenite occurs in two relatively large deposits in Bigwood Township, northeast of Georgian Bay; in extensive deposits along the north shore of Lake Superior near Port Coldwell; and in small occurrences adjacent to Sturgeon Lake, east of Sioux Lookout (6).

British Columbia

MacLean et al. (7) identified four deposits of nepheline syenite in the southern portion of the province, i.e., Kruger Mountain, Mount Copeland, Barrière and Trident Mountain.

Alkali bodies in the Kruger Mountain area essentially consist of four sills of nepheline syenite-type composition. This complex encompasses a large body of medium-to coarse-grain nepheline syenite that outcrops between Keremeos and Osoyoos. Recent investigations of samples from this area showed low alumina (14 to 15% Al_2O_3), and high iron oxide ($>0.65\%$ Fe_2O_3). The iron oxide was identified as finely disseminated magnetite.

The Mount Copeland deposit of nepheline syenite and syenite gneisses outcrops on the southern flank of the mountain about 15 km northwest of Revelstoke. The rock primarily consists of orthoclase with nepheline and albite, and minor amphibole, pyroxene and magnetite. Laboratory studies of samples from this deposit showed alumina contents ranging from 17 to 24% Al_2O_3 , and iron oxide from 0.84 to 8.21% Fe_2O_3 .

The Barrière prospect is located 16 km west of the town of Barrière. The host intrusion is one of a series of syenite bodies that trend southeasterly from west of Barrière to east of Kamloops. An occurrence at Mount Lolo, just northeast of Kamloops, has been studied in some detail. Results indicate an average composition of 19.1% Al_2O_3 and 1.3% Fe_2O_3 .

The Trident Mountain occurrence of nepheline syenite gneiss is located about 85 km northeast of Revelstoke. The rock is white to grey in colour and consists of microcline, albite and nepheline, with minor biotite, ilmenite and other minerals. Studies indicated this material was comparable in purity to the Blue Mountain, Ontario deposit, with excellent potential for development. A chemical analysis of a typical sample from this deposit is as follows: 20.73% Al_2O_3 , 8.35% Na_2O , 3.12% K_2O , 1.20% CaO and 0.52% Fe_2O_3 .

Mining and Processing

Nepheline syenite normally is mined from open pits using standard quarrying methods, although underground mining has been carried on in past years in Ontario. The broken ore is stage-crushed by jaw, cone or impact crushers, and ground by rod mill or roll crusher to about 840 μm . Iron oxide and iron-bearing minerals are next removed by low- and high-intensity magnetic separators. The resulting glass-grade product is sized by air classifiers or screens to standard specifications. Part of the production may be further ground in ceramic pebble mills or tube mills to produce a more finely ground product for ceramic applications, or jet-milled to produce an even more finely ground product for use as a mineral filler/extender.

The flow diagrams, Fig. 2 and 3, depict crushing, grinding and processing stages for nepheline syenite at the Nephton and Lakefield operations, respectively.

Uses and Specifications

Nepheline syenite is used in the manufacture of container glass and glass fibre insulation, in ceramic whiteware product and glazes, in wall and floor tile compositions, and as a filler/extender in paints, plastics and foam rubber.

Nepheline syenite provides necessary alumina and alkalis in glass manufacture which, in turn, act as flux to reduce melt temperatures. Nepheline syenite normally constitutes from

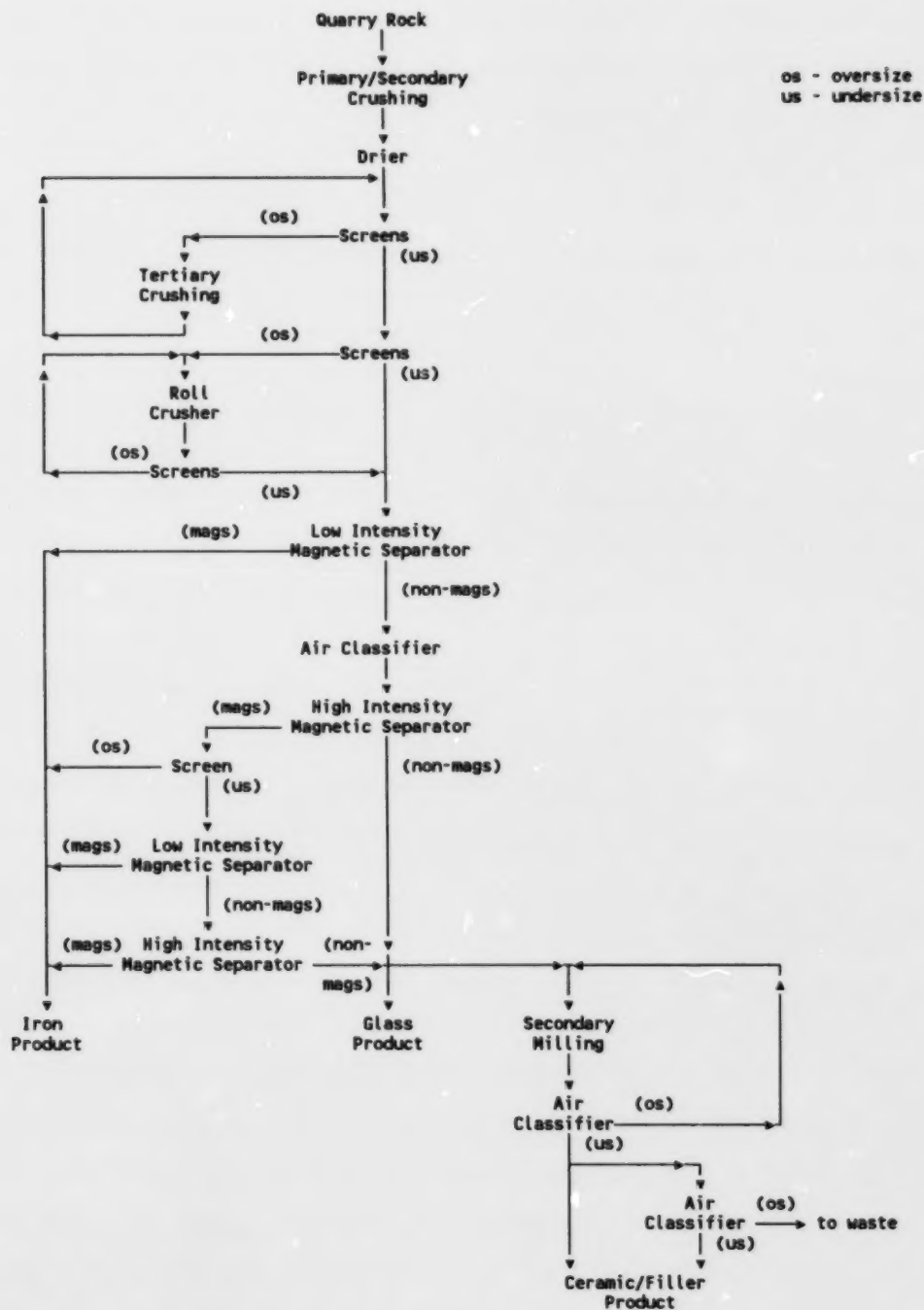


Fig. 2 - Flow Diagram for the Nephton Mill Facility

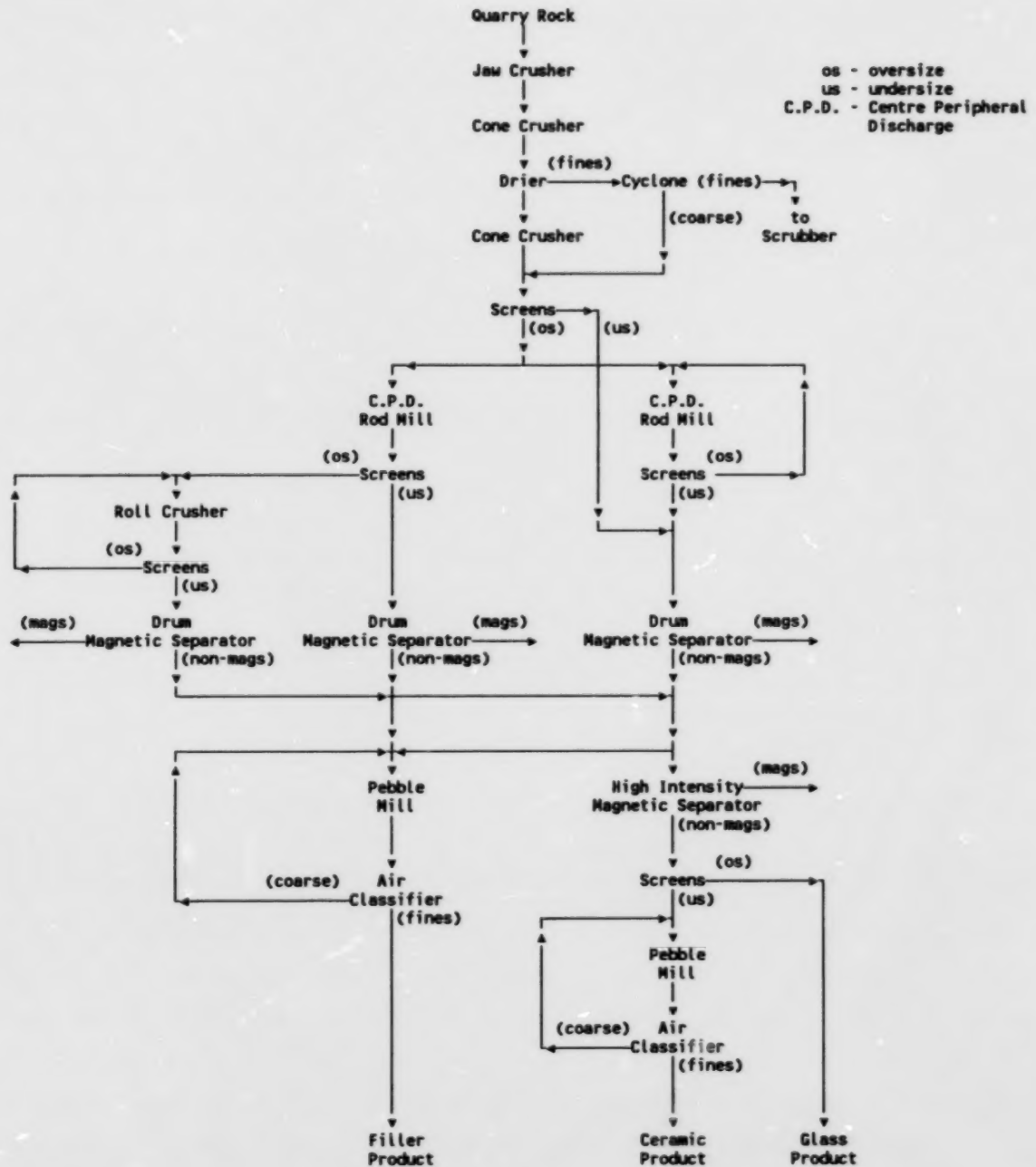


Fig. 3 - Flow Diagram for the Lakefield Mill Facility

15 to 20% of the weight of glass batch materials, is minus 840 plus 600 μm in size, and contains less than 0.1% Fe_2O_3 . The following analysis is typical for glass-grade nepheline:

	%
SiO_2	60
Al_2O_3	24
Na_2O	10.2
K_2O	5.3
CaO	0.3
MgO	0.1
Fe_2O_3	0.07
LOI	0.50

Glass-grade nepheline syenite is ground in pebble mills and sized at minus 75 plus 44 μm for use in ceramic bodies and glazes, when it acts to strengthen the body and to reduce firing temperatures and warpage.

Nepheline syenite for filler and extender applications in paints and plastics is fine-ground to 10 μm . Nepheline syenite in these applications reduces cost by partially substituting for more expensive ingredients such as titanium dioxide and resins. It also aids tint retention in plastics and paint, and reduces chalking in the latter application.

Production and Trade

Hewitt (5) reports that nepheline syenite was first produced in Canada in 1935-36 by Canadian Nepheline Limited from the southwesterly extension of Ontario's Blue Mountain deposit. This company later became American Nepheline Limited and erected a new mill facility at the Nephton quarry site. American Nepheline Limited continued as the sole producer until joined by the Canadian Flint and Spar Company in 1953. This latter company began mining nepheline syenite from the southeasterly extension of the same Blue Mountain deposit, and processing it at a nearby mill. American Nepheline was taken over by

Falconbridge Limited in 1961 and mining was continued under a subsidiary company, Indusmin Limited. Canadian Flint and Spar became Industrial Minerals and Chemicals Limited in 1959, and Sobin Chemicals (Canada) Limited in 1974. Sobin Chemicals was bought out by Indusmin Limited in 1985. Indusmin (now owned by Unimin Corporation) is the sole producer of nepheline syenite in Canada, and continues to operate the two Blue Mountain quarries and processing facilities. Combined processing capacity is 800,000 tpa of finished products.

Production of nepheline syenite gradually rose to 200,000 t in 1958, doubled to 400,000 t by 1967, and reached 600,000 t by 1974. Production continued at that level until 1980, when it fell due to a lessening demand for container glass because of waste glass recycling and competition with aluminum and plastic containers. Production reached a low of 467,491 t in 1986, then gradually rose to over 550,000 t in 1989. Value of production for that year was over \$25 M.

Exports of nepheline syenite in recent years are estimated at 300,000 tpa valued at about \$18 M. The United States is the chief importing country, and annually accounts for about 90% of total Canadian exports. Domestic consumption is about 95,000 tpa, and is used largely in glass and ceramics manufacture.

A summary of production and trade statistics for 1989 and 1990 is reported in Table 1.

Table 1 - Canadian Nepheline Syenite Production, Exports and Consumption, 1989-90

	1989		1990 ^p	
	(tonnes)	(\$000)	(tonnes)	(\$000)
Production (shipments)	551,586	23,077	536,303	24,309
Exports¹				
United States	360,272	15,763	275,682	15,178
Netherlands	32,647	2,358	55,858	4,251
Italy	14,265	865	24,767	1,658
Spain	1,773	217	6,525	906
Japan	659	105	1,854	524
Taiwan	798	118	3,867	798
Australia	573	88	2,958	647
France	361	106	465	161
United Kingdom	236	45	6,353	435
Belgium-Luxembourg	180	40	36	6
Other countries	531	118	3,688	426
Total	412,295	19,823	382,053	24,990
Consumption²				
Primary glass and containers	47,951	-		
Ceramic products	16,452	-		
Paints	8,274	-		
Others ³	15,983	-		
Total	88,660	-		

Sources: Statistics Canada; Energy, Mines and Resources Canada.

¹ Beginning in 1988, exports and imports are based on the new Harmonized System and may not be in complete accord with the previous method of reporting.

² Available data, as reported by consumers.

³ Includes glass-fibre wool and glass fibre, plastics, structural clay products, pulp and paper and paper products, and other minor uses.

- Not available.

^p Preliminary.

FELDSPAR

Mineralogy and Geology

Feldspar is a general name for a group of light-coloured, coarse-grained aluminum silicates of potassium, sodium and calcium, which commonly occur associated with quartz in granite pegmatites. These minerals, in pure form, may be represented by the structural formulas: KAlSi_3O_8 (potash feldspar, microcline, or orthoclase), $\text{NaAlSi}_3\text{O}_8$ (soda feldspar, albite), and $\text{CaAl}_2\text{Si}_2\text{O}_8$ (calcium feldspar, anorthite). These feldspars seldom occur as pure minerals, but rather as three-component mineral complexes. Feldspar varies from white to red or brown, has a hardness of 6 on Mohs' scale, and a specific gravity of 2.5 to 3.0. Commercial feldspar commonly is recovered from granite pegmatites, where it is closely associated with quartz. Accessory minerals usually include muscovite, biotite and, occasionally, tourmaline, pyrite and magnetite.

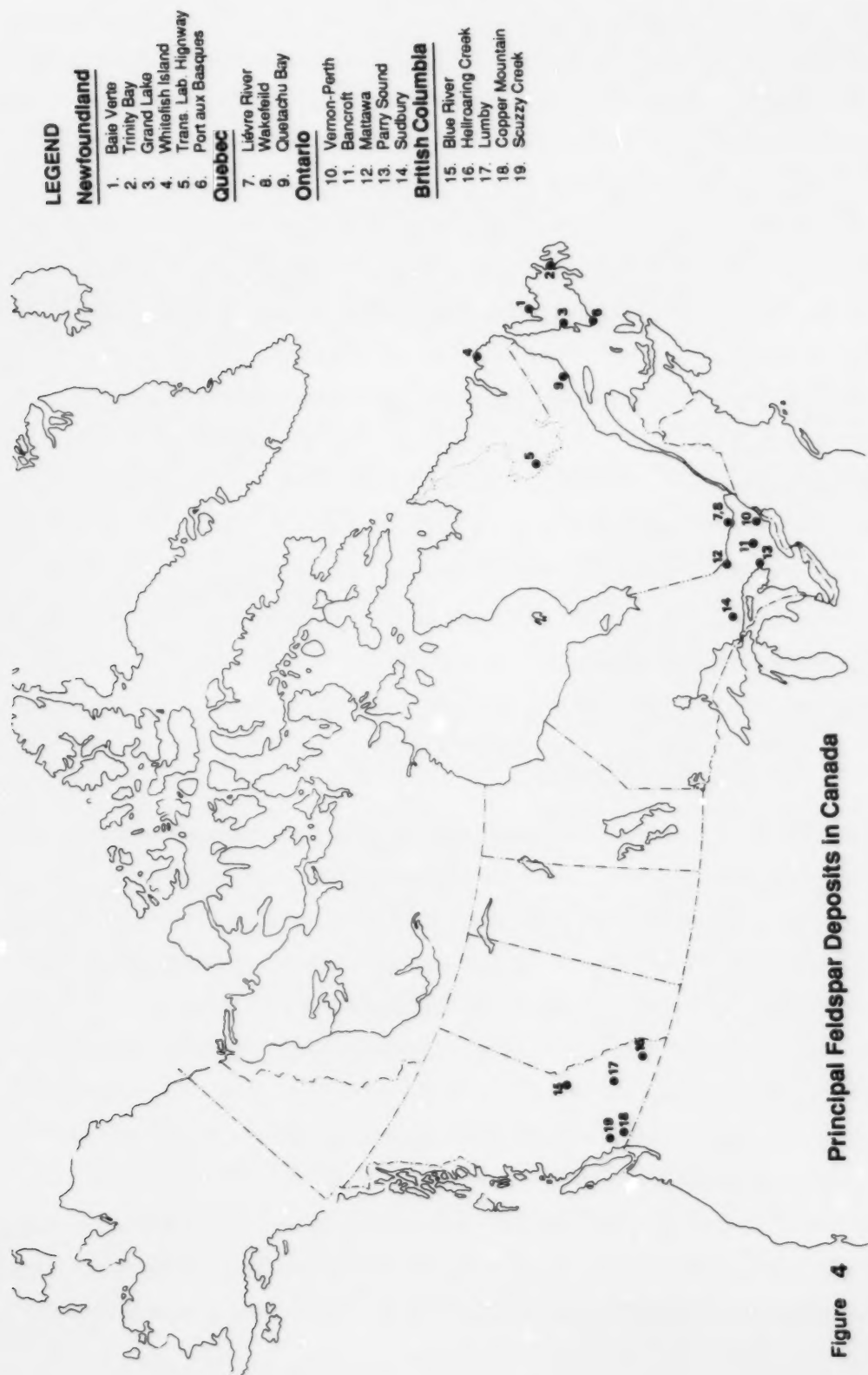
Principal Occurrences

Feldspar occurrences have been recorded in all provinces except Prince Edward Island. Deposits of possible commercial interest, however, are largely confined to five provinces: Newfoundland, Ontario, Quebec, Manitoba and British Columbia. These are described as follows and noted in Fig. 4:

Newfoundland

Carr (8) notes the occurrence of pegmatite dykes, with potential for the recovery of feldspar, at Partridge Point and Hardy Harbour in the Baie Verte area on the northeast coast.

Pegmatite dykes are also reported in the Trinity Bay area on the east coast, and near the southwest end of Grand Lake in the western part of the province. Carr further notes that anorthosite, a rock composed almost entirely of plagioclase, occurs in large quantity at Indian Head and east of St. Georges, St. Georges Bay, on the west coast.



There are twenty-four known occurrences of feldspar in Labrador. The St. Michaels Bay area, southeastern Labrador, is cut by a major north-northwest trending mafic dyke, and by many quartz-potash-feldspar-biotite pegmatites. A provincial geological examination of several of these, including two large pegmatites on Whitefish Island, was conducted in 1987. One deposit was noted as being 3 to 5 m wide, steeply dipping, and largely composed of potash feldspar, quartz and mica. Coarsely crystalline pink feldspar, with some crystals measuring up to 25 cm in diameter, constituted about 85% of this particular pegmatite (9).

Meyer and Dean (9) report several intersections of 3 to 6 m wide mica-quartz-feldspar pegmatites between Emeril and Twin Falls on the Trans Labrador highway between Labrador City and Churchill Falls.

An extensive pegmatite vein outcrops on the southwest coast of Newfoundland, 9 km east of Port aux Basques (10). This vein has an average width of 15 m over a length of 500 m. It is primarily composed of pink microcline with associated quartz and biotite.

Quebec

Spence (11) notes that most of the early production of feldspar in this province was from the Lièvre River district, in Papineau County, north of Buckingham. There were more than forty former operating mines in this area. Other occurrences and mining operations are noted in Argenteuil, Hull and Labelle Counties, and in Saguenay County, near Quetachu Bay. The Derry Mine, located about 15 km north of Buckingham, was the largest producer in Quebec, and ranked next to Ontario's Richardson Mine as a producer of feldspar in Canada. Hébert (12) lists over fifty occurrences of feldspar in the Wakefield area, west of Buckingham. Many of these pegmatite deposits were operated for both quartz and feldspar between 1890 and 1965, and particularly during two periods, 1895 to 1899, and 1921 to 1932.

The Quetachu Bay deposit, also known as the Cape Feldspar deposit, is on the north shore of the St. Lawrence River near Baie Johan Beetz. This pegmatite deposit has been investigated

as a potential source of feldspar for export on a number of occasions. It was operated for a short period in the late 1950s by Spar Mica Corporation, and is now held by Minaco Equipment (13).

Ontario

Feldspar is a common constituent of pegmatites in southeastern Ontario. Spence (11) identifies six main areas, and briefly describes over 100 or more mining operations in these areas prior to 1932. These areas are listed below with the number of former mines in brackets.

Verona, Frontenac County (28)

Bancroft, Hastings County (17)

Sudbury, Sudbury district (16)

Mattawa, Nipissing district (13)

Parry Sound, Parry Sound district (8)

Perth, Lanark County (18)

The Richardson Mine, located northeast of Verona and 5 to 6 km east of Godfrey, reportedly was the largest feldspar mine in Canada. This mine was operated as an open pit during two periods, 1901 to 1918, and 1928 to 1932, when average production rates were about 15,000 tpa. Spence notes occurrences and minor mining activity in several other counties including Carleton, Haliburton and Renfrew, and in Kenora district. There is no mining of feldspar in any of these districts at present.

British Columbia

MacLean and White (14) identify and describe four pegmatite-type feldspar deposits, and one deposit of feldspathic sand in the southern part of the province as follows: Blue River, Hellroaring Creek, Lumby, Copper Mountain, and Scuzzy Creek (feldspathic sand).

The Blue River deposit, which is 3 km west of Blue River and about 500 km south of Valemount, consists of coarse-grained feldspar and quartz with accessory mica. This deposit was drilled by Indusmin Limited in 1984, and samples were evaluated by IMD Limited of Toronto. Results showed good potential for the recovery of industrial-grade feldspar for glass and ceramics.

The Hellroaring Creek pegmatite is 20 km southwest of Kimberley. Microcline and plagioclase feldspar are the principal constituents, and account for 60 to 70% of the mass of the pegmatite. Accessory minerals include muscovite, quartz, biotite, tourmaline and garnet. This deposit was explored by Lumbarton Mines in the early 1980s. Results indicated that the deposit has potential as a source of feldspar for ceramics. A news release by Bearcat Explorations in 1989 noted proven and probable feldspar reserves of 150 Mt.

The Lumby deposit, located 13 km east of the town of Lumby, occurs in a pegmatite stock which is approximately 1.4 by 2.7 km in area and contains four distinct rock types: pegmatites, quartz-mica schists, carbonates and quartz diorites. The pegmatites are typically composed of 70 to 75% feldspar, 20 to 25% quartz, and 5 to 15% mafic minerals with associated biotite, muscovite and garnet. Brenda Mines Limited recently investigated pegmatite from this deposit as a source of glass and ceramic-grade feldspar. Tests on ground feldspar by Clayburn Refractories Limited indicated that material from this deposit had good glaze-forming properties.

Coarse-grained pegmatite occurs in the core of the Copper Mountain stock, a 1.2 by 2.0 km intrusive body located 16 km east of Princeton. Chemical analyses of perthitic feldspar from this stock gave values ranging from 4.5 to 8.5% Na_2O , 19 to 21% Al_2O_3 , and 62 to 65% SiO_2 , which indicated potential as a source of feldspathic material for glass and ceramics. Preliminary beneficiation studies on a sample from this deposit by CANMET showed low recovery and unacceptable high iron oxide levels.

A large feldspathic sand deposit occurs along the banks of Scuzzy Creek, 12 km south of North Bend. Plagioclase and quartz are the chief mineral constituents of this sand; minor minerals include mica and amphibole. The deposit is 400 by 1800 m in size and up to 60 m in thickness. The indicated reserves are large, and relatively easy access gives this deposit good potential for the recovery of feldspar for glass and ceramics. Although preliminary beneficiation studies by CANMET on a submitted sample showed low recovery, the product showed high contents of sodium, calcium and aluminum oxides and less than 1% iron: 8.4% Na_2O , 5.5% CaO , 21.0% Al_2O_3 , 56-59% SiO_2 .

Mining and Processing

There has been no mining of feldspar in Canada during the past 18 to 20 years; mining methods, however, were generally similar to those described earlier for nepheline syenite. Processing and beneficiation of feldspar are also similar to nepheline syenite with two main exceptions: the early use of electrostatic separation to remove quartz, and the later introduction of flotation to concentrate feldspar after removal of other deleterious mineral impurities. A typical flotation operation consists of flotation of iron oxides usually garnetiferous followed by flotation of muscovite and, after activation, feldspar. The "tailing" is an enriched quartz product which may be suitable as glass sand.

Uses and Specifications

Feldspar is used as a source of alumina and alkalis in the manufacture of glass, and in ceramic bodies and glazes. Potash feldspar finds special use in high-voltage electrical insulators. Whiter grades of feldspar are used as dental spar in the manufacture of artificial teeth.

Feldspar has largely been replaced by nepheline syenite in glass manufacture, the latter having a higher content of alumina; however, feldspar continues to be used in ceramics. Potash feldspar containing 8 to 10% K_2O , minimal Na_2O , and less than 0.1% Fe_2O_3 , is

preferred for ceramic applications when it acts as a flux in firing whiteware bodies and glazes. There are three product sizes: 420 μm (glass), 75 μm , and 44 μm (ceramics). Ground feldspar is used in the manufacture of cleaning powders and as a filler/extender in paints, plastics and rubber. A white colour and no abrasive quartz are necessary requirements in most applications.

Production and Trade

Feldspar mining in Canada dates back to 1890, when a production of 700 t from the Buckingham area of Quebec was recorded (11). The Buckingham area continued as the main feldspar production source in Quebec for over 80 years, the principal mines being the Derry and Back. Quebec was joined by Ontario in the early 1900s, when feldspar deposits were discovered and developed in the Verona district north of Kingston and, later, near Bancroft, Sudbury, Mattawa and Perth. The Richardson Mine in the Verona district was the main source of feldspar in Ontario and Canada for many years.

Canadian production of feldspar peaked in 1947 at 55,000 t but subsequently declined because of its gradual replacement by nepheline syenite in glass manufacture, the main market for feldspar at that time. Feldspar production virtually ended in 1972 with the closure of the Back Mine and Buckingham processing plant by Canada's sole remaining producer, International Minerals and Chemical Corporation (Canada) Limited. Producer's shipments in that year amounted to about 10,000 t.

Limited quantities of feldspar were produced in the later 1950s by Spar Mica Corporation Limited from a pegmatite deposit on the north shore of the St. Lawrence River near Baie Johan Beetz, and by Quebec Lithium Corporation as a by-product of its spodumene operation at Barraute, Quebec. Significant and sustained production, however, was not achieved at either operation. Minor quantities of high-grade crude feldspar are occasionally recovered from the Lachaine Quarry at Saint Pierre de Wakefield and from the Perkins Mine for export to markets in the United States (15).

Canada's requirements of feldspar for use in ceramics is obtained from the United States. Consumption data for 1988 and 1989 are shown in Table 2.

Table 2 - Canadian Feldspar Consumption¹, 1988-89

	1988	1989 ^p
Consumption		
Ceramic products	2,489	1,926
Other products ²	85	123
Total	2,574	2,049

Source: Energy, Mines and Resources Canada.

¹ Available data, as reported by consumers.

² Includes adhesives, abrasives and other minor uses.

^p Preliminary.

Current Interest

At present, there is very little production of feldspar in Canada; however, interest has been expressed by several companies in feldspar deposits in Quebec, Manitoba and British Columbia (16,17).

Bearcat Explorations is studying the possibility of developing a pegmatite deposit at Hellroaring Creek, 20 km southwest of Kimberley in southeastern British Columbia, for the production of several industrial minerals including feldspar, mica and silica. The objective would be to produce a feldspathic product suitable for the glass, fibreglass and ceramic industry. Mica would be sold to the drywall, cement, paint and drilling mud industries, and quartz could be used in glass-making and other applications.

Brenda Mines Limited is also studying the possibility of developing a pegmatite for the production of feldspar, mica and silica. The deposit is located 13 km east of Lumby, British Columbia. Markets for feldspar in British Columbia would be the western provinces

in Canada, the Pacific northwest states and northern California in the United States, and possibly southeast Asia.

Tantalum Mining Corporation of Canada Limited (TANCO) of Bernic Lake, Manitoba, reported that its project of recovering feldspar as a by-product of its spodumene operation had been put on hold due to unfavourable economic conditions. The feldspar, which is rich in rubidia (1.3% Rb_2O) and high in potassium oxide (9.5% K_2O), would be in demand for the manufacture of high-voltage electrical insulators that require 15 to 50% K-feldspar by weight; other applications would include glass and ceramic products. Some 27,000 t of feldspar could be recovered annually.

The Cape Feldspar (Quetachu Bay) pegmatite formation, which is a few km east of the village of Johan-Beetz on the north shore of the St. Lawrence River, has been examined in recent years as a potential source of feldspar for the United States and overseas markets. Two companies, Ressources Canspar Ltée and Minaco Equipment Limited, are actively involved. Exploratory work to date has outlined ore reserves of 35 Mt down to mean sea level. Drill core sample analyses indicated a feldspar content of 60 to 69% consisting, on average, of 29% K-feldspar, 26% Na-feldspar and 6% Ca-feldspar, with mica, quartz and minor accessory minerals comprising the remainder. Testwork by IMD Laboratories, Toronto, indicated potential recoveries of 50 to 60% feldspar with low iron oxide and good alumina and alkali values (15).

CANMET STUDIES

Background

Twenty-eight CANMET nepheline syenite beneficiation studies (18-46), and two by other organizations (47,48) were reviewed. Seventeen CANMET studies of feldspar beneficiation were reviewed (49-65), and two by other organizations (66,67). Summaries of CANMET nepheline syenite studies are presented in Appendix 1, and studies by other organizations in

Appendix 2. Summaries of CANMET feldspar studies are reported in Appendix 3, and studies by other organizations in Appendix 4.

The summary of each study includes, if known, the original sample weight, head analysis, mineralogy, beneficiation methods, beneficiation product sizes, concentrate grades and recoveries, and remarks or observations of particular interest. The original sample weight is indicative of the scale of investigation, whether bench, laboratory, semi-pilot plant or pilot plant. The head analyses provide data concerning the mineral content and whether the sample originates from a high or low-grade deposit. Mineralogical information not only identifies major and minor minerals, but also provides data regarding association between minerals and host rocks. The liberation size in many cases is either not known or not stated; the beneficiation product size is quoted since, by inference, product size under optimum test conditions usually equates to liberation size. Beneficiation methods are important as a guide for future studies of ores with similar mineral assemblages, and concentrate grade and recovery figures provide an indication of how efficient the beneficiation methods were in achieving a specification product. Additional data regarding flotation parameter and reagent concentration are also reported. Studies common to a particular deposit, when possible, are grouped together for continuity and convenience of reference.

CANMET and its predecessor, Mines Branch, conducted the nepheline syenite and feldspar studies between 1931 and 1990. The majority of nepheline syenite studies were conducted on samples from Ontario; most feldspar studies were conducted on samples from Nova Scotia and Quebec.

A summary of process data for nepheline syenite beneficiation studies is reported in Table 3, and of analytical data in Table 4. Feldspar beneficiation process data is similarly reported in Table 5, and analytical data in Table 6.

Table 3 - Summary of Process Data for Nepheline Syenite Beneficiation Studies

Location	No. of samples	Sample wt (kg)	Product sizes μm	Process methods	Ref. No.
Ontario					
Methuen twp.	1	6.4	-840 +420; -420 +150; -150	Crushing, sizing, magnetic separation	18
Methuen twp.	1	1.6 t	-840 +180	Crushing, screening, magnetic separation	19
Methuen twp.	1	169	-600	Crushing, jigging, flotation, magnetic separation	20
Bancroft	1	1.6 t	-600 +150; -150 +75; -75	Crushing, screening, magnetic separation	21
Bancroft	1	495	-840 +600; -600 +420; -420 +300	Crushing, screening, magnetic separation, air classification	22
Bancroft	5	450	-420	Crushing, screening, magnetic separation	23
Bancroft	2	55	-420	Crushing, magnetic separation	24
Bancroft	15	480	-840	Crushing, magnetic separation, glass melt evaluation	46
Lakefield	2	1.8 t	-710	Crushing, grinding, flotation, classification, magnetic separation	25
Lakefield	1	1.4 t	-710	Crushing, grinding, flotation, classification, magnetic separation	26
Lakefield	1	153 t	-600	Crushing, screening, grinding, flotation, tabling	27
Lakefield	1	976	-150	Screening, deliming, flotation, magnetic separation	29
Lakefield	1	182	-19 +4.8 mm; -4.8 mm	Crushing, sizing, aggregate evaluation	30
Lakefield	1	16.8	-600	Crushing, magnetic separation	31
Lakefield	1	19	-600	Crushing, magnetic separation	32
Dungannon twp.	2	14	-840	Crushing, screening, magnetic separation	33
Dungannon twp.	1	4.5	-840	Magnetic separation	34
Dungannon twp.	1	35	-840	Crushing, magnetic separation, flotation	35
n.s.	1	61 t	-300 +150; -150	Grinding, flotation, spiral concentration*, wet screening, magnetic separation	36
Monteagle twp.	1	n.s.	n.s.	Ceramic evaluation, colour and sag testing, impact testing, translucency trials	37
Monteagle twp.	1	8.2 t	-600	Grinding	38
n.s.	2	2.3 t	-600	Grinding	39
Port Coldwell	13	13	-420 +150; -150	Grinding, sizing, magnetic separation	40
Port Coldwell	6	120	-600 +300; -300 +150; -150 +44; -44	Crushing, screening, magnetic separation	41
Port Coldwell	1	45	-600 +150	Crushing, wet screening, magnetic separation	48
Naphton	6	20	n.s.	Magnetic separation	
n.s.	1	100	-3	Air classification	
n.s.	1	55	-600	Grinding, magnetic separation	
British Columbia					
n.s.	1	n.s.	-600; -600 +210; -150; -44	Crushing, grinding, sizing, magnetic separation	42
Death Rapids	1	30	-25 +12.5 mm; -12.5 + 6.7 mm; -840	Crushing, screening, ceramic evaluation, tabling, magnetic and electrostatic separation, flotation	43
Kruger Mountain	5	n.s.	-420 +150	Grinding, screening, magnetic separation	44
Kruger Mountain	2	45	-840 +150	Crushing, sizing, magnetic separation	45
Osoyoos	1	10	-75 +44; -44	Flotation	45
			-840 +420; -420 +100	Crushing, sizing, magnetic separation	46

*Humphreys spiral

Table 4 - Summary of Analytical Data for Nepheline Syenite Beneficiation Studies

Location	Head analysis %		Product sizes μm	Product analysis %		Recovery %	Ref. No.
	Fe ₂ O ₃	Al ₂ O ₃		Fe ₂ O ₃	Al ₂ O ₃		
Ontario							
Methuen twp.	n.s.	n.s.	-840 +420	0.09	n.s.	n.s.	18
			-420 +150	0.12	n.s.	n.s.	18
			-150	0.17	n.s.	n.s.	18
Methuen twp.	1.16	n.s.	-840 +180	n.s.	n.s.	n.s.	19
Methuen twp.	1.33	n.s.	-600	0.045	n.s.	60.0	20
Bancroft	1.16	23.16	-600 +150	0.032	n.s.	n.s.	21
			-150 +75	0.018	n.s.	76.0	21
			-75	0.10	n.s.	n.s.	21
Bancroft	2.84	28.42	n.s.	0.08	29.50	n.s.	22
Bancroft	n.s.	n.s.	-420	0.11*	n.s.	n.s.	23
Bancroft	n.s.	n.s.	-420	n.s.	n.s.	n.s.	24
Bancroft	0.538*	n.s.	-840	0.057*	n.s.	80.0	47
Lakefield	1.41	n.s.	-710	0.133	n.s.	85.5	25
	3.37	n.s.	-710	0.306	n.s.	58.8	25
Lakefield	1.30	24.81	-600	0.31	n.s.	89.0	26
Lakefield	1.04	n.s.	-150	0.132	n.s.	55.9	27
Dungannon twp.	n.s.	n.s.	-600	0.12	n.s.	68.2	30
	n.s.	n.s.	-600	0.08	n.s.	65.4	30
Dungannon twp.	1.25	24.12	-840	0.10	24.47	n.s.	31
Dungannon twp.	2.75	30.53	-840	0.24	33.03	56.6	32
n.s.	n.s.	n.s.	-840	0.37	n.s.	n.s.	33
Monteagle twp.	5.50	n.s.	-300	0.07	29.1	n.s.	34
Port Coldwell	n.s.	n.s.	-420 +150	0.36*	n.s.	n.s.	37
			-150	n.s.	n.s.	n.s.	37
Port Coldwell	5.20	20.20	-600 +300	0.56	21.88	48.6	38
			-300 +150	0.52	21.91	10.0	38
			-150 +44	0.40	21.93	9.1	38
Port Coldwell	2.74	n.s.	-600 +150	0.40	n.s.	n.s.	39
Nephton	n.s.	n.s.	-600	0.038	n.s.	n.s.	48
British Columbia							
n.s.	n.s.	n.s.	-600 to -44	0.60*	n.s.	n.s.	42
Kruger Mountain	4.70*	n.s.	-420 +150	>0.10	n.s.	n.s.	44
Kruger Mountain	n.s.	n.s.	-150 +75	0.08	n.s.	n.s.	45
			-75	0.08	n.s.	n.s.	45
Osoyoos	6.70	17.4	-420 +100	0.44	20.2	27.8	46

*Average

n.s. - not stated

Table 5 - Summary of Process Data for Feldspar Beneficiation Studies

Location	No. of samples	Sample wt (kg)	Product sizes μm	Process methods	Ref. No.
New Brunswick					
St. George	1	175	-420	Crushing, flotation, wet tabling	49
Nova Scotia					
New Ross	1	300	-300	Grinding, flotation	50
n.s.	1	91	-420	Crushing, acid leaching, desliming, flotation, magnetic separation	51
n.s.	1	n.s.	-1.7 mm to +75	Crushing, screening, magnetic separation, electrostatic separation	52
n.s.	1	n.s.	-840; -300	Crushing, screening, magnetic separation, flotation	53
n.s.	1	91	-420	Hand sorting, crushing, grinding, flotation	54
Quebec					
Buckingham	2	n.s.	+6.7 mm; -6.7 mm	Sizing, colour sorting	56
Chateau Richer	1	68	-44	Grinding, screening, filler evaluation	57
Chateau Richer	1	n.s.	-75	Grinding, washing, magnetic separation, wall tile and structural clay evaluation	58
Chateau Richer	1	n.s.	-44	Facing brick evaluation	59
Chateau Richer	1	n.s.	-75	Grinding, washing, magnetic separation, wall tile and floor tile evaluation	60
Thurso	1	14	50% -75	Hand sorting, grinding, screening, brightness determinations	61
Thurso	1	227	-75	Pilot plant grinding and screening trials	62
Magdalen Isld.	1	40	+250; -250	Flotation, magnetic separation, acid leaching, alkali scrubbing	63
Manitoba					
Bernic Lake	1	90	-420; -75; -44	Heavy liquid separation, grinding, screening, glass-melt evaluation	66
Bernic Lake		n.s.	-300	Grinding, flotation, brightness determinations	67
British Columbia					
Armstrong	1	90	+3.4 mm; -3.4 +1.7 mm -1.7 +1.2 mm; -1.2 mm +850; -850 +600; -600 +420	Hand sorting, crushing, screening, air tabling	64
Barrière	1	2	-210 +53	Crushing, grinding, desliming, flotation, magnetic separation	65

n.s. - not stated

Table 6 - Summary of Analytical Data for Feldspar Beneficiation Studies

Location	Head Analysis %			Product sizes μm	Product analysis %		Recovery %	Ref. No.
	Qtz	Feld	Fe ₂ O ₃		Feld	Fe ₂ O ₃		
<u>New Brunswick</u>								
St. George	60	35	n.s.	-420	65	n.s.	n.s.	49
<u>Nova Scotia</u>								
New Ross	15	80	2.29	-300	90**	0.36	41.3	50
n.s.	39	52	6.93*	-420	91**	0.20	50	51
n.s.	35	55	7.71*	-1.7 mm +210	96	n.s.	n.s.	52
				-210 +150	88	n.s.	n.s.	52
				-150 +75	66	n.s.	n.s.	52
n.s.	34	58	6.16*	-300	n.s.	0.07	n.s.	53
n.s.	n.s.	n.s.	n.s.	-420	98**	0.48	67.2	54
<u>Quebec</u>								
Buckingham	n.s.	n.s.	n.s.	+6.7 mm; -6.7 mm	98**	0.021	88.8; 83.8	56
	n.s.	n.s.	n.s.	+6.7 mm; -6.7 mm	98**	0.021	66.0; 54.0	56
Magdalen Isld.	30	70	0.61	-250 (porcelain)	91**	0.049	n.s.	63
				-250 (ceramic)	91**	0.076	n.s.	63
				-250 (glass)	93**	0.11	n.s.	63
<u>Manitoba</u>								
Bernic Lake	n.s.	n.s.	n.s.	-420; -75; -44	95**	0.043	n.s.	66
Bernic Lake		75	n.s.	-300	85	n.s.	64.3	67
<u>British Columbia</u>								
Barrière	97	1.17		-210 +53	>99	0.11	n.s.	65

* Calculated from the theoretical chemical composition of biotite

** Calculated using the formula:

$$\% \text{ Feldspar} = \frac{\% \text{K}_2\text{O}}{16.92} + \frac{\% \text{Na}_2\text{O}}{11.82} + \frac{\% \text{CaO}}{20.16} \times 100$$

Scale

The feed weight for most nepheline syenite studies was less than 500 kg; seven studies (19,21,25,26,27,34,36) were conducted on samples weighing 1 t or more. The feed weight for feldspar studies was less than for nepheline syenite; the maximum feed weight was 300 kg (50).

Head Analyses

The mineralogical analyses of nepheline syenite samples were generally not reported. An analysis of between 65 and 70%, however, can be considered representative. The mineralogical analysis of feldspar samples varied from 35% feldspar in a quartz-feldspar ore from St. George, New Brunswick (49), to 97% feldspar in a high-grade feldspar ore from Barrière, British Columbia (65). The feldspar analysis for most ores was greater than 50%.

Mineralogy

Nepheline syenite was associated with basic igneous and basaltic-rock minerals including quartz, feldspar, hornblende, muscovite, phlogopite, biotite, chlorite, corundum, magnetite, hematite, garnet, scapolite, zircon, scheelite, pyrite, pyrrhotite, apatite and sphene. Feldspar was associated chiefly with quartz. Minor minerals included biotite, muscovite, chlorite, magnetite, hematite, garnet, hornblende, sericite, apatite, fluorite, calcite, molybdenite, pyrite and chalcopyrite.

Analysis Reporting

The analysis of nepheline syenite and feldspar was generally not reported chemically because of the occurrence of other alumina-containing minerals. An analysis for concentrated nepheline syenite and feldspar products can be inferred from the closeness to the theoretical alumina content of the pure minerals. The theoretical alumina (Al_2O_3) content for nepheline

syenite is 23.5 to 24.2% and, for feldspar, 18.3 to 19.4%. The only reliable indication of chemical purity is the Fe_2O_3 content which is reported for both head and concentrated products. A requirement for nepheline syenite and feldspar is that the Fe_2O_3 should be very low, which specification has been previously discussed.

Beneficiation

Nepheline Syenite

The beneficiation of nepheline syenite samples was fairly straightforward generally involving only crushing, screening and magnetic separation. Flotation, when employed, was used to float accessory minerals such as biotite (33), muscovite (20,34), corundum (20,25), magnetite (26) and miscellaneous iron-containing minerals (27,45), base-metal sulphide minerals (34) and, in two studies, nepheline syenite (43,45). A summary of collector and modifier concentration data is reported in Table 7, and principal flotation parameter data in Table 8.

Corundum and magnetite were also beneficiated by gravity concentration techniques because each mineral is characterized by a relatively high specific gravity. Thus, jigging was employed to concentrate corundum and magnetite (20), and Humphreys Spiral to concentrate corundum (34). Air separation was used in one study to separate mica and magnetite (22), and wet tabling was used in another to concentrate muscovite (34). Air separation was also used to size nepheline syenite down to 3 μm (41).

The attainment of specification-grade nepheline syenite was variable. An analysis of less than 0.1% Fe_2O_3 was achieved with certain beneficiated ore samples from Methuen Township (18,20), Bancroft (21,22,47), Dungannon Township (30,31), Monteagle Township (34) and Nephton (48) in Ontario, and Kruger Mountain (45) in British Columbia. The iron oxide analyses for most of the remaining beneficiated samples were less than 0.4%.

Table 7 - Summary of Reagent Concentration Data for Nepheline Syenite and Feldspar Flotation

Location	Minerals floated	HF g/t	Fuel oil g/t	Oleic acid g/t	Cresylic acid g/t	Armour series ² g/t	Petroleum sulphonate ³ g/t	Duomeen TDO g/t	Ref. No.
1. Nepheline syenite									
Methuen twp., Ont.	Corundum	-	300	342 ¹	-	-	-	-	20
	Muscovite	-	-	-	-	25	-	-	20
Bancroft, Ont.	Corundum	-	-	430	-	110	-	-	25
	Corundum	-	-	730	-	185	-	-	25
Lakefield, Ont.	Magnetite}	-	-	215	-	-	-	-	26
	Corundum}	-	-	-	-	-	-	-	26
Lakefield, Ont.	Muscovite	-	-	-	-	20	-	-	26
	Iron oxides ³	-	540	410	50	-	155	-	27
n.s., Ont.	Biotite	-	-	700 ¹	-	-	-	-	33
Death Rapids, B.C.	Nepheline syenite	-	-	348	-	-	-	-	43
Kruger Mtn, B.C.	Iron oxides ³	-	150	-	-	-	500	-	45
2. Feldspar									
St. George, N.B.	Feldspar ⁵ (Ro)	2000	-	-	-	100	-	-	49
	(Cl)	500	-	-	-	-	-	-	49
New Ross, N.S.	Molybdenite	-	-	-	700 ⁴	-	-	-	50
	Feldspar (Ro)	625	2750	-	50	1100	-	-	50
Magdalen Isld., Que.	(Cl)	-	850	-	-	-	450	-	63
	Feldspar (Ro)	-	-	-	-	-	-	750	63
Que.	(Cl)	-	-	-	-	-	-	200	63
Bernic Lake, Man.	Feldspar	-	-	-	-	-	-	1600	67

¹Includes sodium oleate

²Primary amine collectors

³Includes ferro magnesian minerals

⁴Cyanamid "700" and "800" series

⁵Ro - Rougher

Cl - Cleaner

⁶Coal oil

Table 8 - Summary of Principal Parameter Data for Nepheline Syenite and Feldspar Flotation

Location	Minerals floated	Float time min	pH	Pulp density % Solids	Ref. No.
1. Nepheline syenite					
Methuen twp., Ont.	Corundum	9	n.s.	n.s.	20
	Muscovite	6	n.s.	30	20
Bancroft, Ont.	Corundum	n.s.	9.5	45	25
	Corundum	n.s.	9.6	40	25
Lakefield, Ont.	Magnetite	n.s.	9.3	39	26
	Corundum				
Lakefield, Ont.	Iron oxides	7	6.5	n.s.	27
n.s., Ont.	Biotite	17	8.9	n.s.	33
Death Rapids, B.C.	Nepheline Syenite	5	n.s.	n.s.	43
2. Feldspar					
New Ross, N.S.		5		n.s.	50
	Molybdenite	22	9.1	n.s.	50
	Feldspar	5	3.0	55	63
Magdalen Isld., Que.	Feldspar (Ro)	4	2.1	16	63
	Feldspar (Cl)	10	2.4	n.s.	67
Bernic Lake, Man.	Feldspar		2.4		

A number of product evaluation studies for nepheline syenite included glass melt evaluation (47), aggregate evaluation (29), fired brick evaluation (28), and ceramic evaluation (35,43).

Feldspar

The beneficiation of feldspar basically involved crushing and grinding followed by flotation, and magnetic separation to remove magnetic material. Flotation generally involved the removal of iron oxide minerals followed by muscovite and, finally, feldspar leaving an enriched quartz 'tailing'. In one study, molybdenite was floated prior to feldspar (50). A summary of collector and modifier concentration data is reported in Table 7, and for principal parameter data in Table 8.

A variety of miscellaneous techniques used to beneficiate feldspar included wet tabling (49), hand cobbing (54,61), air tabling (64), heavy liquid separation (66), electrostatic separation (52), acid leaching (51,63), and colour sorting (56).

The production of high-grade $>90\%$ feldspar was possible with most samples. A high-grade feldspar, however, was not always consistent with a low iron oxide content. The attainment of less than 0.1% Fe_2O_3 was reported for a few beneficiated ore samples: from Nova Scotia (53), from Buckingham and Magdalen Islands in Quebec (56,63), from Bernic Lake in Manitoba (66), and from Barrière in British Columbia (65).

A product evaluation study, which included a glass melt evaluation, was conducted on an ore sample from Bernic Lake, Manitoba (66). Product evaluation studies were also conducted on several samples of material from Chateau Richer, Quebec: filler evaluation (57), wall tile and structural clay evaluation (58), facing brick evaluation (59), and wall tile and floor tile evaluation (60).

CONCLUDING COMMENT

This report is the eleventh in a Summary Report series on industrial minerals. These reports are designed to assist individuals or companies having interest in industrial minerals in Canada. A wide distribution of the Summary Report series is planned as a means of encouraging interest in the further development of industrial minerals for use in many diverse applications. These uses vary from fillers for everyday products such as paint and rubber to high-performance plastics in the high-technology sector.

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APPENDIX 1

SUMMARIES OF CANMET NEPHELINE SYENITE STUDIES



ONTARIO

- Identification : Ont.-1 (Ref. No. 18)
- Report - Title : THE TESTING OF SYENITE FROM METHUEN
TOWNSHIP FOR THE REMOVAL OF IRON
- Author : R.K. Carnochan
- No. and Date : *Ore Dressing Investigation Report* 413 (1931)
- Sample Description : A 6.4 kg sample of nepheline syenite composed of albite, microcline and nepheline. Minor minerals included magnetite and muscovite.
- Objective : To produce a glass-grade product.
- Processing : Crushing to pass 840 μm with a minimum production of minus 75 μm fines. The crushed product was sized to produce minus 840 plus 420 μm , minus 420 plus 150 μm , and minus 150 μm fractions. Each size fraction was passed through a dry, high-intensity Ullrich magnetic separator.
- Results : The minus 840 plus 420 μm fraction, representing 36.5% of the feed, analyzed 0.09% Fe_2O_3 . The minus 420 plus 150 μm fraction analyzed 0.12% Fe_2O_3 , and the minus 150 μm fraction analyzed 0.17% Fe_2O_3 .
- Potential Use : The minus 840 plus 420 μm fraction, only, is suitable as glass or ceramic-grade.

Identification	: Ont.-2 (Ref. No. 19)
Report - Title	: BENEFICIATION OF NEPHELINE SYENITE FROM METHUEN TOWNSHIP
- Author	: R.K. Carnochan
- No. and Date	: <i>Ore Dressing Investigation Report</i> (unnumbered) (1935)
Sample Description	: A 1.58 t sample of white nepheline syenite, also containing some magnetite and chlorite, analyzing 1.16% Fe_2O_3 .
Objective	: To reject the magnetite.
Processing	: The sample was crushed to minus 840 μm and screened at 180 μm . The minus 840 plus 180 μm fraction was passed through a dry high intensity magnetic separator to reject magnetite.
Results	: Analyses were not reported, although the separation was reported as being successful.
Potential Use	: Not applicable.

- Identification : Ont.-3 (Ref. No. 20)
- Report - Title : THE REMOVAL OF CORUNDUM, MAGNETITE AND MICA FROM A CORUNDUM-RICH NEPHELINE SYENITE ROCK OBTAINED FROM METHUEN TOWNSHIP
- Author : H.S. Smedley
- No. and Date : *Ore Dressing Investigation Report* 4306 (1943)
- Sample Description : A 169 kg sample of corundum-rich, nepheline syenite rock, associated with magnetite and muscovite, analyzing 5.05% corundum and 1.33% Fe_2O_3 .
- Objective : To produce a separate high-grade corundum concentrate, and a nepheline syenite product low in iron oxide and corundum.
- Processing : Crushing to pass 600 μm with a minimum production of minus 75 μm fines. A corundum and magnetite concentrate were separated by jigging. The jig tailing was subjected to flotation to separate a corundum concentrate, followed by a muscovite concentrate. The concentrated nepheline syenite tailings were further beneficiated by magnetic separation.
- Results : Jigging produced a corundum concentrate analyzing 69.8% corundum and 11.9% Fe_2O_3 . Flotation and magnetic separation produced a nepheline syenite concentrate analyzing 0.14% corundum, 0.045% Fe_2O_3 for a recovery of about 60%.
- Potential Use : Corundum may be suitable for abrasive use after further beneficiation. Nepheline syenite is suitable for glass manufacture and possibly for certain ceramic applications.

- Identification : Ont.-4 (Ref. No. 21)
- Report - Title : THE ELIMINATION OF IRON FROM A SAMPLE OF NEPHELINE SYENITE OBTAINED FROM STONEY LAKE
- Author : R.K. Carnochan
- No. and Date : *Ore Dressing Investigation Report* (unnumbered) (1935)
- Sample Description : A 1.58 t sample of nepheline syenite ore associated with minor amounts of magnetite and light green mica, analyzing 1.16% Fe_2O_3 and 23.16% Al_2O_3 .
- Objective : To reduce the iron oxide content to $<0.1\%$ Fe_2O_3 .
- Processing : Crushing by gyratory and rolls crushers to pass 600 μm , followed by screening to produce minus 600 plus 150 μm , minus 150 plus 75 μm , and minus 75 μm fractions. Each fraction was passed over on Ullrich high-intensity magnetic separator, and the non-magnetic fractions passed over a Dings magnetic separator.
- Results : The non-magnetic fractions, after passing over the Dings separator, analyzed 0.032% Fe_2O_3 for minus 600 plus 150 μm , 0.018% Fe_2O_3 for minus 150 plus 75 μm , and 0.10% Fe_2O_3 for the minus 75 μm fractions. The combined recovery was 76%; 65% for the minus 600 plus 150 μm , and 11% for the minus 150 plus 75 μm .
- Potential Use : The minus 600 plus 150 μm , and minus 150 plus 75 μm fractions are low enough in iron to be considered suitable for glass or ceramic-grade nepheline syenite.

A-45

Identification : Ont.-5 (Ref. No. 22)

Report - Title : REPORT ON A SHIPMENT OF NEPHELINE SYENITE FROM BANCROFT

- Author : C.H. Freeman

- No. and Date : *Ore Dressing Investigation Report* (unnumbered) (1938)

Sample Description : A 495 kg sample of nepheline syenite ore analyzing 2.84% Fe_2O_3 , 0.13% TiO_2 and 28.42% Al_2O_3 .

Objective : To produce glass-grade nepheline syenite with a minimum production of minus 53 μm material.

Processing : Crushing to pass 840 μm , followed by screening on successive screen sizes from 840 to 53 μm . The sized product was passed through a Dings magnetic separator to remove magnetic impurities. An air separation test, to remove mica and magnetite, was conducted on the minus 840 plus 600 μm , minus 600 plus 420 μm , and minus 420 plus 300 μm fractions.

Results : Magnetic separation produced the best results with a nepheline syenite concentrate analyzing 0.08% Fe_2O_3 , 0.02% TiO_2 and 29.50% Al_2O_3 .

Potential Use : Suitable as glass-grade nepheline syenite.

Identification	: Ont.-6 (Ref. No. 23)
Report - Title	: REPORT OF LABORATORY TEST ON NEPHELINE SYENITE FROM THE PRINCESS QUARRY, BANCROFT
- Author	: C.G. Bruce
- No. and Date	: <i>Industrial Minerals Report</i> 216 (1953)
Sample Description	: Five samples of nepheline syenite ore weighing in total 450 kg, associated with biotite, hornblende, magnetite and some pyrite.
Objective	: To produce ceramic-grade nepheline syenite.
Processing	: Each sample was crushed to 840 μm and screened on 300 μm and 150 μm to produce fractions for magnetic separation using a laboratory CarpcO magnetic separator. Initial indications were that the liberation size was about 420 μm , so that magnetic separation was not successful above this size. Further magnetic separation was conducted on samples ground to minus 420 μm .
Results	: The iron oxide contents of the five samples after magnetic separation were between 0.091% and 0.134% Fe_2O_3 .
Potential Use	: Unsuitable for ceramic-grade without further beneficiation, although possibly suitable 'as is' for amber-grade glass sand.

A-47

Identification : Ont.-7 (Ref. No. 24)

Report - Title : REPORT OF LABORATORY TEST ON NEPHELINE
SYENITE FROM BANCROFT

- Author : C.G. Bruce

- No. and Date : *Industrial Minerals Report* 231 (1954)

Sample Description : A 55 kg sample of the minus 840 plus 420 μm , and minus
420 plus 150 μm fractions from sample 5 referred to in
Industrial Minerals Report 216.

Objective : To produce ceramic-grade nepheline syenite.

Processing : Crushing to pass 420 μm , followed by passing through a
belt-type magnetic separator to remove strongly magnetic
minerals. The non-magnetic fraction was then passed
several times through the Exolon magnetic separator at
various settings.

Results : No analyses were reported, but visual examination of the
Exolon non-magnetic fractions indicated inclusions of iron
minerals still attached to the nepheline syenite surfaces.

Potential Use : Unsuitable as ceramic-grade nepheline syenite.

- Identification : Ont.-8 (Ref. No. 25)
- Report - Title : FLOTATION OF NEPHELINE SYENITE FROM THE LAKEFIELD AND BANCROFT AREAS
- Author : F.R. Archibald
- No. and Date : *Ore Dressing Investigation Report* 1028 (1941)
- Sample Description : A 1.82 t sample of corundum-rich ore from the Blue Mountain quarry, designated Sample A, and a 1.36 t sample of nepheline syenite from Bancroft, designated Sample B. The head analysis of Sample A was 1.41% Fe_2O_3 and 1.25% corundum, and of Sample B, 3.37% Fe_2O_3 .
- Objective : To produce high-grade nepheline syenite concentrates low in iron oxide and alumina.
- Processing : Crushing to pass 9.5 mm, followed by ball mill grinding in closed circuit with a 710 μm Hammer screen. Iron oxide and corundum were then separated by pilot-plant scale flotation. The enriched nepheline syenite tailings were classified in a Hardinge classifier, the underflow dried and shipped for final magnetic separation. The classifier overflow was thickened, filtered, dried and also shipped for final magnetic separation.
- Results : The best result obtained with Sample A was a nepheline syenite concentrate analyzing 0.133% Fe_2O_3 and 0.02% corundum for a weight recovery of 85.5%. The best result obtained with Sample B was a nepheline syenite concentrate analyzing 0.306% Fe_2O_3 for a weight recovery of 58.8%.
- Potential Use : Possibly suitable for amber-grade glass sand.

- Identification : Ont.-9 (Ref. No. 26)
- Report - Title : PILOT PLANT INVESTIGATION ON A NEPHELINE SYENITE ROCK DEPOSIT FROM LAKEFIELD
- Author : W.T. Turrall
- No. and Date : *Ore Dressing Investigation Report 2020 (1946)*
- Sample Description : A 153 t sample of white nepheline syenite ore analyzing 24.81% Al_2O_3 , 1.30% Fe_2O_3 , 0.46% corundum and 0.55% CaO. The iron minerals included magnetite, hematite, pyrite, pyrrhotite and biotite. Minor minerals also included scheelite, muscovite, corundum, zircon and scapolite.
- Objective : To develop a flowsheet, so that specification-grade glass and ceramic-grade nepheline syenite could be produced.
- Processing : Secondary crushing by either jaw or gyratory crusher to minus 40 mm, followed by tertiary crushing using a Symons cone crusher set at 50 mm. The minus 600 μm material from the crusher discharge was separated by screening. Grinding to 100% minus 600 μm with a minimum amount of minus 75 μm material was conducted using a low-discharge Marcy rod mill. Wet and dry grinding were evaluated, and wet grinding was preferred because of increased grinding capacity. It was noted that liberation was not complete at 600 μm . Following grinding nepheline syenite was beneficiated by a combination of flotation and tabling. Flotation involved first removal of magnetite and corundum, followed by muscovite. The enriched nepheline syenite 'flotation tailing' was then deslimed and tabled to remove any remaining impurities.
- Results : The best results were a nepheline syenite product analyzing 0.31% Fe_2O_3 , 0.06% corundum with a recovery of 89% by weight. The Fe_2O_3 content was further reduced by high-intensity magnetic separation, but analyses were not reported.
- Potential Use : Iron oxide levels too high for clear glass manufacture.

A-50

Identification : Ont.-10 (Ref. No. 27)

Report - Title : CONCENTRATION TESTS ON SHIPMENTS OF
GRADE B NEPHELINE SYENITE FROM LAKEFIELD

- Author : H.L. Beer

- No. and Date : *Mineral Dressing Investigation Report 2660* (1950)

Sample Description : A 976 kg sample of nepheline syenite ore associated with
minor amounts of magnetite, biotite, muscovite and
phlogopite. The head analysis indicated 1.04% Fe_2O_3 .

Objective : To produce a nepheline syenite product analyzing
<0.10% Fe_2O_3 .

Processing : Wet screening to remove plus 150 μm magnetite,
desliming to remove very fine material, and flotation of
iron-containing minerals. The enriched nepheline syenite
tailings were then passed through a Frantz Ferro Filter
magnetic separator to further reduce the iron oxide
content.

Results : A nepheline syenite concentrate analyzing 0.132% Fe_2O_3
with a recovery of 55.9% of the nepheline syenite was
obtained. An analysis of 0.10% Fe_2O_3 in the nepheline
syenite was only possible by reducing the recovery of
nepheline syenite to 38.9%.

Potential Use : Suitable as a source of alumina in glass manufacture.

Identification	: Ont. -11 (Ref. No. 28)
Report - Title	: A REPORT TO DETERMINE THE EFFECT OF NEPHELINE SYENITE ON THE FIRED PROPERTIES OF MIXTURES OF BRICK RAW MATERIALS
- Author	: J.G. Brady
- No. and Date	: <i>Industrial Minerals Report</i> 458 (1957)
Sample Description	: Samples of ground Dundas shale and Weston surface clay, and A200 pottery grade and B200 impure grade nepheline syenite from Lakefield, Ontario.
Objective	: To determine whether nepheline syenite might reduce the absorption, increase the strength, and so improve the quality of a buff brick.
Processing	: The clay was dried and crushed to pass 1.2 mm, but the shale and nepheline syenite needed no further treatment. Hand-molded briquettes were made up of various proportions of clay and shale, and always with 5% nepheline syenite. The dried and fired properties were determined.
Results	: The addition of ground nepheline syenite had very little effect on the absorption, colour and strength of bodies containing mixtures of Dundas shale and Weston surface clay. A mixture containing 80% shale, 20% clay with an addition of 5% A200 or B200 nepheline syenite tended to reduce the absorption slightly and increase the fired shrinkage.
Remarks	: There was no improvement in either hardness or absorption, because the softening point and highest possible firing temperature of the clay and shale were too low to permit a good reaction with the more refractory nepheline syenite.
Potential Use	: Not determined.

- Identification : Ont.-12 (Ref. No. 29)
- Report - Title : REPORT ON TESTS MADE ON WASTE ROCK FROM LAKEFIELD, ONTARIO FOR USE AS AGGREGATE
- Author : F.E. Hanes
- No. and Date : *Industrial Minerals Report* 467 (1957)
- Sample Description : A 182 kg sample of waste rock composed of 65% nepheline syenite, 25% biotite schist, and 10% miscellaneous silicate minerals.
- Objective : To produce a product suitable for aggregate use.
- Processing : The aggregate evaluation procedure is set out under various ASTM* test procedures. These include unit weight, crushing and sizing to produce coarse (minus 19 plus 4.8 mm) and fine aggregate (minus 4.8 mm), bulk specific gravity and absorption, Los Angeles abrasion test, and magnesium sulphate soundness test.
- Results : The following results were reported:
- | | |
|-----------------------|-------|
| Bulk Specific Gravity | 2.62 |
| Absorption | 1.88% |
| Abrasion | 36.2% |
| Sulphate Soundness | 3.93% |
- These results were considered inferior to standard hot-laid "commercial" coarse aggregate.
- Potential Use : Unsuitable as coarse aggregate.

*American Society for Testing Materials

A-53

Identification : Ont.-13 (Ref. No. 30)

Report - Title : REPORT ON MAGNETIC SEPARATION TESTS ON
TWO SAMPLES OF NEPHELINE SYENITE ORE
FROM DUNGANNON TOWNSHIP

- Author : C.H. Freeman

- No. and Date : *Ore Dressing Investigation Report* (unnumbered) (1938)

Sample Description : Two samples of nepheline syenite ore: Sample A
weighing 16.8 kg was from "East Hill", and Sample B
weighing 19 kg was from "West Hill".

Objective : To produce ceramic and glass-grade nepheline syenite.

Processing : Crushing to pass 600 μm , followed by magnetic separation
using a Dings high-intensity magnetic separator.

Results : A nepheline syenite concentrate analyzing 0.12% Fe_2O_3
with a recovery of 68.2% was produced from Sample A
material. A nepheline syenite concentrate analyzing 0.08%
 Fe_2O_3 with a recovery of 65.4% was produced from
Sample B material.

Potential Use : Suitable for glass and ceramic use.

Identification	: Ont.-14 (Ref. No. 31)
Report - Title	: REPORT ON A SAMPLE OF NEPHELINE SYENITE FROM DUNGANNON TOWNSHIP SUBMITTED FOR MILLING TESTS
- Authors	: R.K. Carnochan and C.H. Freeman
- No. and Date	: <i>Ore Dressing Investigation Report</i> (unnumbered) (1938)
Sample Description	: A 14 kg sample of nepheline syenite ore associated with biotite in thick flakes up to 25 mm in size. The head analysis was 1.25% Fe ₂ O ₃ , 0.10% TiO ₂ and 24.12% Al ₂ O ₃ .
Objective	: To determine whether biotite could be scalped off at a coarse size before magnetic separation of finer size material.
Processing	: Stage crushing to 4.8 mm using a Rolls crusher, followed by screening at 840 μ m. The minus 4.8 mm plus 840 μ m was again crushed by the Rolls crusher, and this time screened at 1.7 mm. The plus 1.7 mm fraction was coarse biotite. The minus 1.7 mm fraction was screened at 840 μ m and the plus 840 μ m crushed to pass 840 μ m. The combined minus 840 μ m fractions were passed through a Dings high-intensity magnetic separator to produce a low-iron nepheline syenite product.
Results	: The coarse biotite fraction analyzed only 25% biotite suggesting that the scalping operation was worthwhile. The non-magnetic fraction of nepheline syenite analyzed 0.10% Fe ₂ O ₃ , 0.02% TiO ₂ and 24.47% Al ₂ O ₃ .
Potential Use	: Suitable as glass and ceramic grades.

A-55

Identification	: Ont.-15 (Ref. No. 32)
Report - Title	: REPORT ON MAGNETIC SEPARATION TESTS ON A SMALL SHIPMENT OF MINUS 840 μm NEPHELINE SYENITE FROM DUNGANNON TOWNSHIP
- Author	: C.H. Freeman
- No. and Date	: <i>Ore Dressing Investigation Report</i> (unnumbered) (1938)
Sample Description	: A 4.5 kg sample of minus 840 μm nepheline syenite analyzing 2.75% Fe_2O_3 , 0.14% TiO_2 and 30.53% Al_2O_3 .
Objective	: To reduce the iron oxide level to 0.07% Fe_2O_3 .
Processing	: Magnetic separation using a Dings high-intensity magnetic separator.
Results	: A nepheline syenite concentrate analyzing 0.24% Fe_2O_3 , 0.03% TiO_2 and 33.03% Al_2O_3 with a weight recovery of 56.6% was obtained.
Potential Use	: Unsuitable as glass or ceramic-grade, but may be suitable for amber-grade glass sand.

A-56

Identification : Ont.-16 (Ref. No. 33)

Report - Title : PROGRESS REPORT ON INVESTIGATIONS OF A
NEPHELINE SYENITE ORE

- Author : J.F. Wright

- No. and Date : *Ore Dressing Investigation Report* (unnumbered) (1943)

Sample Description : A 35 kg sample of nepheline syenite ore associated with
biotite.

Objective : To produce glass or ceramic-grade nepheline syenite.

Processing : Crushing to pass 840 μm , followed by passing over a
Dings magnetic separator. An attempt was made to
further reduce the iron oxide level by flotation of the
biotite.

Results : The iron oxide level could only be reduced to 0.37%
 Fe_2O_3 .

Potential Use : Unsuitable as glass or ceramic-grade, but may be suitable
for amber-grade glass sand.

Identification	: Ont.-17 (Ref. No. 34)
Report - Title	: BENEFICIATION OF NEPHELINE SYENITE FROM MONTEAGLE TOWNSHIP TO ESTABLISH PLANT PROCESS PARAMETERS
- Authors	: L. Moyd., P. Moyd and H.L. Noblitt
- No. and Date	: <i>Ore Dressing Investigation Report</i> (unnumbered) (1950)
Sample Description	: A 61 t sample consisting of a 68% mixture of nepheline syenite, feldspar and scapolite, 10% muscovite, 14% biotite and 2% corundum. Minor minerals included calcite, magnetite and base metal sulphides. The iron oxide head analysis was 5.5%.
Objective	: To produce separate nepheline syenite, corundum and muscovite concentrates for product evaluation.
Processing	: Grinding to pass 300 μm followed by first, flotation to remove base metal sulphide minerals, and then flotation to recover a muscovite concentrate. The flotation tailings were then passed over a Humphreys Spiral to recover coarse corundum. Flotation was conducted on the spinel tailing to recover first, a bulk corundum, calcite and spinel concentrate, and then flotation to remove biotite. The final flotation tailings, containing nepheline syenite, were wet screened at 150 μm . Each size fraction was dried and separately passed through a high-intensity magnetic separator to remove biotite. The muscovite product was further upgraded by wet tabling, and the corundum product by a combination of drying, screening, air tabling and magnetic separation.
Results	: A total of 9 t of nepheline syenite were produced analyzing 29.1% Al_2O_3 and 0.07% Fe_2O_3 . A glass-melt test evaluation proved positive.
Potential Use	: Suitable for ceramic and glass-grade uses.

- Identification : Ont.-18 (Ref. No. 35)
- Report - Title : REPORT OF INVESTIGATION INTO THE POSSIBLE
USE OF NEPHELINE SYENITE FROM MONTEAGLE
TOWNSHIP AS A CERAMIC FLUX
- Author : J.F. Wright
- No. and Date : *Mineral Dressing Investigation Report* C2683 (1950)
- Sample Description : A sample of concentrated nepheline syenite.
- Objective : To determine whether the nepheline syenite was a suitable
replacement for feldspar when firing to make whiteware
bodies.
- Processing : Various dinnerware, sanitary ware, china and tile ware
were prepared. The following trial pieces were made up
from each body: colour, sag, translucency and impact.
Firing was to cones 6, 8 and 10; colour trial pieces were
tested for colour, hardness, absorption and shrinkage. Sag
trial pieces were supported over a 178 mm span during
firing, and the amount of sag was measured. The wedge-
shaped translucency trial pieces were placed over a pinhole
light source, and the thickness of the piece measured when
the light was obscured. Impact tests were conducted on a
Tinius Olsen impact machine.
- Results : Monteagle syenite is not as effective a flux as feldspar,
and in most cases its use results in a body with a higher
absorption. There is a shorter vitrification range, so that
bodies fluxed with the nepheline syenite would show a
greater tendency to warp than those fluxed with feldspar.
- Potential Use : Monteagle nepheline syenite could not be used as a
substitute for feldspar.

A-59

Identification	: Ont.-19 (Ref. No. 36)
Report - Title	: GRINDING OF NEPHELINE SYENITE IN A CENTRE PERIPHERAL DISCHARGE ROD MILL
- Author	: R.A. Simpson
- No. and Date	: <i>Industrial Minerals Report</i> 303 (1954)
Sample Description	: An 8.2 t sample of 9.5 mm nepheline syenite ore, and a 2.3 t sample of 19 mm nepheline syenite ore from Nephton.
Objective	: To establish grinding parameters for the production of granular minus 600 μm with a minimum of minus 75 μm material.
Processing	: Grinding trials were conducted using a laboratory Marcy centre peripheral discharge rod mill with internal dimensions of 0.6 by 1.2 m. Simulated closed circuit conditions were conducted using a 600 μm screen at a feed rate of 23.6 kg/min, and a mill load of 401 kg of rods.
Results	: The best result was a minus 600 μm , ground product with only 10.4% minus 75 μm material. The work index varied from 3.58 to 5.27 kwh/t.
Potential Use	: Not applicable.

A-60

Identification	: Ont.-20 (Ref. No. 37)
Report - Title	: BENEFICIATION OF SAMPLES OF SYENITE FROM THE PORT COLDWELL AREA
- Author	: J.E. Reeves
- No. and Date	: <i>Mineral Processing Test Report</i> 60-115 (1960)
Sample Description	: Thirteen samples, each weighing about 1 kg, and ground and sized to produce minus 420 plus 150 μm , and minus 150 μm fractions. Mineralogical examination indicated the presence of major feldspar with hornblende, nepheline syenite, apatite and various opaque iron oxide minerals.
Objective	: To produce ceramic or glass-grade nepheline syenite.
Processing	: Magnetic separation using a Frantz iso-dynamic separator.
Results	: The lowest iron oxide analyses varied from 0.33 to 0.38% Fe_2O_3 .
Potential Use	: Unsuitable for glass or ceramic, although may possibly be suitable for amber glass.

A-61

- Identification : Ont.-21 (Ref. No. 38)
- Report - Title : BENEFICIATION OF NEPHELINE SYENITE FROM PORT COLDWELL
- Author : F.H. Hartman
- No. and Date : *Mineral Processing Test Report* 63-3 (1963)
- Sample Description : Six samples, designated A to F, and each weighing about 20 kg. The first five samples were drill core; sample F was a lump of 200 to 300 mm size. Mineralogical examination indicated the feldspar to be filled with tiny inclusions of hornblende in all samples. The analysis of sample C was 5.20% Fe_2O_3 and 20.20% Al_2O_3 .
- Objective : To produce glass or ceramic-grade nepheline syenite.
- Processing : It was decided to process only sample C, since the hornblende was somewhat coarser than in the other samples. Crushing to pass 600 μm followed by screening to produce minus 600 plus 300 μm , minus 300 plus 150 μm , minus 150 plus 44 μm , and minus 44 μm . Each size fraction was passed through the Jones high-intensity magnetic separator.
- Results : The iron oxide contents of the various screen fractions were between 0.56% and 0.40% Fe_2O_3 . The alumina contents were between 21.88% and 21.93% Al_2O_3 for the minus 600 plus 44 μm fractions.
- Potential Use : Unsuitable for glass or ceramic-grade, although possibly suitable for amber-grade glass at 0.4% Fe_2O_3 .

Identification	: Ont.-22 (Ref. No. 39)
Report - Title	: MAGNETIC TREATMENT OF NEPHELINE SYENITE FROM PORT COLDWELL
- Author	: F.H. Hartman
- No. and Date	: <i>Mineral Processing Test Report</i> 69-3 (1969)
Sample Description	: A 45 kg sample of nepheline syenite ore analyzing 2.74% Fe ₂ O ₃ .
Objective	: To reduce iron oxide to <0.1%.
Processing	: Crushing to pass 600 μ m with the production of 24% minus 44 μ m, followed by wet high-intensity magnetic separation using the Jones separator. The non-magnetic fraction was wet screened at 150 μ m, dried, and passed over a laboratory CarpcO magnetic separator.
Results	: The iron oxide level was reduced to 0.40%.
Potential Use	: Unsuitable for glass or ceramic-grades, although possibly suitable for amber-grade glass.

A-63

Identification : Ont.-23 (Ref. No. 40)

Report - Title : MAGNETIC SEPARATIONS ON SIX SAMPLES OF
NEPHELINE SYENITE FROM NEPHTON

- Author : F.H. Hartman

- No. and Date : *Mineral Processing Test Report 61-75 (1961)*

Sample Description : Marginal and waste products from the nepheline syenite
plant operation at Nephton. The six samples comprised
two lots: lot 1 was composed of samples B-100L, B-100
and B-dust, each of 4.5 kg weight; lot 2 comprised
samples A-270, A-400 and B-1000, each of 2.3 kg weight.
The head analyses were: B-100L, 0.17% Fe_2O_3 ; B-100,
0.64% Fe_2O_3 ; B-dust, 1.05% Fe_2O_3 ; A-270, 0.066%
 Fe_2O_3 ; and A-400, 0.066% Fe_2O_3 .

Objective : To determine whether the iron oxide levels could be
further reduced.

Processing : Magnetic separation trials using the Jones wet high-
intensity separator and the Frantz Ferro Filter separator.

Results : The non-magnetic products were lower in iron oxide
content than the feed material, but not sufficiently low to
warrant further testing.

Potential Use : Not applicable.

A-64

Identification : Ont.-24 (Ref. No. 41)

Report - Title : THE RECOVERY OF MINUS TWO MICRON
NEPHELINE SYENITE BY AIR CLASSIFICATION

- Author : R.A. Wyman

- No. and Date : *Mineral Processing Test Report* 68-7 (1968)

Sample Description : A 100 kg sample of ground, 80% minus 10 μm , nepheline syenite.

Objective : To produce a classified product of minus 2 μm .

Processing : Air classification using an Alpine Microplex spiral air classifier, Model 132 MP. The main variables, air-inlet vein opening, feed rate, size distribution, feed-inlet size opening, and coarse-product outlet size opening, were optimized before attempting the main run to produce a bulk coarse and fine product.

Results : The weight recovery was 27.2% fines and 65.3% coarse with a loss of 7.5%. The size split appeared to be about 3 μm .

Potential Use : Not applicable.

BRITISH COLUMBIA

Identification	: B.C.-1 (Ref. No. 42)
Report - Title	: REDUCTION OF IRON IN A SAMPLE OF SYENITE FROM BRITISH COLUMBIA
- Author	: W.J.D. Stone
- No. and Date	: <i>Mineral Processing Test Report</i> 60-61 (1960)
Sample Description	: A sample of altered porphyritic syenite obtained from the southern part of British Columbia, associated with feldspar and muscovite.
Objective	: To reduce the iron oxide content so that a product suitable for the ceramic industry could be produced.
Processing	: Crushing to pass 1.7 mm, followed by grinding in a pebble mill to four different sizes: minus 600 μm , minus 600 plus 210 μm , minus 150 μm , and minus 44 μm . Each size fraction was passed through the Jones wet high-intensity magnetic separator.
Results	: The iron oxide content was reduced to between 0.40% and 0.79% Fe_2O_3 .
Remarks	: The high iron oxide levels were due to the prevalence of fine-grained, iron-bearing, micaceous alteration products.
Potential Use	: Unsuitable for ceramic or glass-grade use, although there is a possible use, at 0.4% Fe_2O_3 , for amber-grade glass.

A-66

Identification	: B.C.-2 (Ref. No. 43)
Report - Title	: THE CONCENTRATION OF CYANITE FROM DEATH RAPIDS, BIG BEND DISTRICT
- Author	: R.K. Canrochan
- No. and Date	: <i>Ore Dressing Investigation Report</i> 471 (1931)
Sample Description	: A 30 kg sample of nepheline syenite ore in white quartz with minor phlogopite.
Objective	: To concentrate the nepheline syenite for ceramic use.
Processing	: Crushing to pass 25 mm, followed by screening to produce minus 25 plus 12.5 mm, minus 12.5 plus 6.7 mm and minus 6.7 mm fractions. Each of the coarser fractions were carefully hand-picked for further ceramic evaluation. The minus 6.7 mm material was further ground to minus 840 μ m and beneficiated by tabling, magnetic and electrostatic separation and flotation. Flotation was used to produce further concentrate for ceramic evaluation.
Results	: Flotation produced the highest grade concentrate analyzing 58.5% Al_2O_3 ; recoveries, however, were only fair. Ceramic evaluation indicated that the nepheline syenite converts to mullite with a decrease in specific gravity from 3.62 to 3.04, and specimens containing from 88 to 98% nepheline syenite showed linear expansions from 8 to 16%.
Potential Use	: Ceramic evaluation indicated use for refractory applications.

A-67

Identification	: B.C.-3 (Ref. No. 44)
Report - Title	: BENEFICIATION OF SAMPLES OF NEPHELINE SYENITE FROM KRUGER MOUNTAIN
- Author	: J.E. Reeves
- No. and Date	: <i>Mineral Processing Test Report</i> 60-110 (1960)
Sample Description	: Four samples, designated A, B, C and D. Each sample consisted of microcline, nepheline syenite, hornblende, plagioclase and biotite. Minor minerals included garnet, sphene, apatite and magnetite. The iron oxide analyses indicated that Samples B and C contained 4% Fe_2O_3 , whereas Sample D being darker, contained 6% Fe_2O_3 .
Objective	: To produce ceramic or glass-grade nepheline syenite.
Processing	: Sample A was too small and sample D too dark to warrant further testwork. Processing of samples B and C included grinding and screening of each sample to produce a minus 420 plus 150 μm size fraction, which was passed through the Frantz isodynamic separator.
Results	: Visual examination of the non-magnetic products indicated that a large proportion of the grains contained small dark inclusions and would analyze greater than 0.1% Fe_2O_3 .
Potential Use	: Unsuitable for glass or ceramic-grade nepheline syenite.

A-68

Identification	: B.C.-4 (Ref. No. 45)
Report - Title	: BENEFICIATION OF NEPHELINE SYENITE FROM KRUGER MOUNTAIN
- Author	: F.H. Hartman
- No. and Date	: <i>Unpublished Results</i> (1970)
Sample Description	: A 45 kg sample of nepheline syenite, mineralogy similar to Test Report 60-110.
Objective	: To produce glass- or ceramic-grade nepheline syenite.
Processing	: Crushing to 840 μm , followed by sizing down to 44 μm , with magnetic separation of each size fraction to determine liberation, which was estimated to be between 150 μm and 75 μm . Flotation was conducted on the non-magnetic portion of the minus 75 plus 44 μm , and minus 44 μm fractions.
Results	: The non-magnetic portion of the minus 150 plus 75 μm fraction analyzed 0.08% Fe_2O_3 . Flotation of the minus 75 μm fractions indicated that a similar analysis value for the nepheline syenite concentrates could be obtained.
Potential Use	: Suitable only in the finer sizes for glass and ceramic use.

A-69

Identification : B.C.-5 (Ref. No. 46)

Report - Title : BENEFICIATION OF A SAMPLE OF NEPHELINE
SYENITE FROM BRITISH COLUMBIA AS SOURCE
MATERIAL FOR THE GLASS INDUSTRY

- Author : P.R.A. Andrews

- No. and Date : *Division Report MSL 86-88 (IR) (1986)*

Sample Description : 10 kg of minus 100 mm ore samples analyzing 17.4%
 Al_2O_3 and 6.70% Fe_2O_3 .

Mineralogy : About 80% nepheline syenite and 10% magnetite with the
remainder comprising miscellaneous silicates.

Processing : Crushing to 840 μm and sizing at 420 and 100 μm with
removal of 100 μm fines. Magnetic separation of minus
840 plus 420 μm , and minus 420 plus 100 μm fractions.

Results : A product analyzing 20.2% Al_2O_3 and 0.44% Fe_2O_3 was
obtained with the minus 420 plus 100 μm fraction;
recovery was low at 27.8%.

Potential Use : Suitable for amber-grade in the production of fibreglass
and foam glass.

APPENDIX 2

**SUMMARIES OF NEPHELINE SYENITE STUDIES
BY OTHER ORGANIZATIONS**



ONTARIO

Identification	: Ont.-25 (Ref. No. 47)
Report - Title	: REPORT ON NEPHELINE SYENITE MINING CLAIMS NEAR BANCROFT
- Author	: S.H. Law
- No. and Date	: <i>Dings Magnetic Separator Co., Milwaukee, U.S.A.</i> (Unpublished) (1936)
Sample Description	: Fifteen drill core samples each weighing about 32 kg and analyzing from 0.181 to 0.895% Fe_2O_3 .
Objective	: To reduce the iron oxide content to a level low enough to permit use of the nepheline syenite in the production of crystal glass.
Processing	: Crushing to pass 840 μm with a production of 10.9% minus 75 μm material. Each sample was then passed through a Dings magnetic separator. A sample of non- magnetic nepheline syenite was evaluated in a glass melt using a sillimanite crucible at 1427°C.
Results	: Magnetic separation results indicate that a nepheline syenite product analyzing between 0.048% and 0.065% Fe_2O_3 , with a recovery of about 80%, could be obtained. Screen analyses with the production of only 10.9% minus 75 μm was satisfactory. The glass melt produced a clear, crystal glass.
Potential Use	: Suitable for the production of crystal glass.

B-74

Identification : Ont.-26 (Ref. No. 48)

Report - Title : THE RECOVERY OF NEPHELINE FROM MAGNETIC
SEPARATOR WASTE

- Author : W.D. Hubler

- No. and Date : *American Nepheline Corporation Report* (unpublished)
(1946)

Sample Description : A 55 kg sample of combined table tails and hydroseparator
underflow from a pilot plant run.

Objective : To produce glass-grade nepheline syenite.

Processing : Dry grinding to minus 600 μm , followed by dry magnetic
separation.

Results : A non-magnetic product analyzing 0.038% Fe_2O_3 and
0.04% corundum was obtained.

Potential Use : Suitable as glass-grade nepheline syenite.

APPENDIX 3

SUMMARIES OF CANMET FELDSPAR STUDIES



NEW BRUNSWICK

Identification : N.B.-1 (Ref. No. 49)

Report - Title : SEGREGATION AND MICROSCOPIC TESTS ON A
SAMPLE OF RED GRANITE FROM A QUARRY IN
ST. GEORGE

- Author : H.L. Beer

- No. and Date : *Ore Dressing Investigation Report 1-47 (1947)*

Sample Description : A 175 kg sample of waste rock consisting of a mixture of
diorite, red and pink granite. The red granite portion was
made up of 60% quartz, 35% feldspar and 5%
hornblende.

Objective : To determine whether the feldspar would be suitable for
the pottery industry.

Processing : Crushing to 420 μ m followed by differential flotation of
feldspar from quartz, after hydrofluoric acid activation of
feldspar, in one test. In a second test, differential flotation
of quartz from feldspar, after lead nitrate activation of
quartz, was attempted. Feldspar concentration was also
attempted by wet tabling.

Results : The best results were obtained by hydrofluoric acid
activation of feldspar, but grades and recoveries were not
optimized since the concentrate analyzed 65% feldspar,
30% quartz and 5% hornblende with mica.

Remarks : Further flotation testwork would be required to upgrade
the feldspar, and magnetic separation to remove ferro-
magnesian minerals from the feldspar concentrate.

Potential Use : Not determined.

NOVA SCOTIA

Identification : N.S.-1 (Ref. No. 50)

Report - Title : CONCENTRATION TESTS ON A MOLYBDENITE,
FELDSPAR, QUARTZ ORE FROM THE NEW ROSS
AREA, LUNENBURG, COUNTY

- Author : H.L. Beer

- No. and Date : *Mineral Dressing Investigation Report 2652 (1950)*

Sample Description : A 300 kg sample analyzing about 80% orthoclase feldspar
with clear glassy quartz comprising the remainder. Minor
amounts of molybdenite, chalcopyrite and pyrite were also
present. Iron minerals, principally biotite, analyzed
2.29% Fe₂O₃.

Objective : To produce glass-grade feldspar.

Processing : Dry grinding to minus 300 μ m, followed by molybdenite
flotation and subsequently feldspar flotation.

Results : A feldspar concentrate analyzing 90% feldspar, 0.36%
Fe₂O₃, and representing a weight recovery of 41.3% was
obtained.

Potential Use : Unsuitable as glass-grade feldspar.

C-79

- Identification : N.S.-2 (Ref. No. 51)
- Report - Title : INITIAL FELDSPAR FLOTATION TRIALS ON A
SAMPLE OF GRANITE FROM NOVA SCOTIA
- Author : R.A. Wyman
- No. and Date : *Industrial Minerals Report* 413 (1956)
- Sample Description : A 91 kg sample of a weathered granite consisting of 52% orthoclase, 39% quartz, 9% biotite with minor muscovite. Alteration was evident on most feldspar grains, and the liberation of feldspar was not complete until 300 μm .
- Objective : To produce glass-grade feldspar.
- Processing : Crushing to 420 μm followed by an acid blunge with sulphuric acid, desliming to remove clay products, flotation of biotite in an acid media, and finally flotation of feldspar from quartz. Magnetic separation was used to reduce the iron oxide level of the feldspar concentrate.
- Results : A feldspar concentrate analyzing 64.1% SiO_2 , 20.1% Al_2O_3 and 0.20% Fe_2O_3 was obtained with a 22% weight recovery, which represented about 50% recovery of feldspar in the feed.
- Potential Use : Unsuitable as glass-grade feldspar.

C-80

- Identification : N.S.-3 (Ref. No. 52)
- Report - Title : RECOVERY OF QUARTZ AND FELDSPAR FROM A NOVA SCOTIA GRANITE SAMPLE
- Author : E.G. de Wolf
- No. and Date : *Industrial Minerals Report* 453 (1957)
- Sample Description : A sample of coarse-grained granite consisting of 55% perthitic orthoclase, 35% quartz and 10% biotite.
- Objective : To produce ceramic-grade feldspar.
- Processing : Crushing to 1.7 mm followed by screening at 840 μm , 600 μm , 420 μm , 300 μm , 210 μm , 150 μm and 75 μm . Each fraction was passed through a laboratory Carpco magnetic separator to remove biotite. The non-magnetic portions of each of the screened products were treated, before electrostatic separation, with an aqueous solution of hydrofluoric acid, which renders feldspar a positive conductor. The surfaces of each mineral, without surface treatment, are negative. After washing and drying, each fraction was passed through a Coronatron, single roll, electrostatic separator using high intensity, positive polarity.
- Results : The grade of feldspar in the plus 210 μm fraction was 94 to 97%. The grade decreased to 88% feldspar for the plus 150 μm fraction, and to 66% feldspar for the plus 75 μm fraction. Feldspar products were nearly all above No. 1 ceramic grade. Recovery, however, was only 19.2% of original sample.
- Potential Use : Possibly suitable for ceramic-grade use.

C-81

- Identification : N.S.-4 (Ref. No. 53)
- Report - Title : CONCENTRATION OF FELDSPAR AND QUARTZ
FROM A SAMPLE OF GRANITE FROM
NOVA SCOTIA
- Author : R.A. Wyman
- No. and Date : *Industrial Minerals Report* 476 (1957)
- Sample Description : A sample of granite from below the zone of weathering,
referred to in *Industrial Minerals Report* 413, consisting of
58% feldspar, 34% quartz and 8% biotite.
- Objective : To produce ceramic-grade feldspar low in iron.
- Processing : Rolls crushing to 840 μm , followed by screening to reject
plus 840 μm biotite. An attempt to remove biotite from
the remaining minus 840 μm portion was made by
magnetic separation and flotation, but the iron oxide
content was not reduced below 0.12% Fe_2O_3 . Flotation of
biotite was improved, when using minus 300 μm material,
with a sulphated red oil - amine/fuel oil combination as
collector. Feldspar was next separated from quartz by
flotation and any remaining biotite was removed from the
feldspar concentrate by magnetic separation.
- Results : The final feldspar product analyzed 0.07% Fe_2O_3 which is
within range of glass-grade feldspar. Recovery, although
not reported, was considered to be reasonable.
- Potential Use : Possibly suitable as glass-grade feldspar, but it was
considered too uneconomic to maintain the low iron values
using this processing route.

Identification : N.S.-5 (Ref. No. 54)

Report - Title : CONCENTRATION OF FELDSPAR AND QUARTZ
FROM A THIRD SAMPLE OF GRANITE FROM
NOVA SCOTIA

- Author : R.A. Wyman

- No. and Date : *Mineral Processing Internal Report 62-58 (1962)*

Sample Description : A 91 kg sample of 200 mm lumps of medium-grained granite pegmatite consisting of pink to brick-red feldspar, quartz, green mica and disseminated grains of molybdenite. Apatite and fluorite were also present in minor amounts.

Objective : To produce glass-grade feldspar.

Processing : Hand sorting to reject waste wall rock, and to produce a high-grade feldspar crystal analyzing 17.8% Al_2O_3 and 0.18% Fe_2O_3 . The remaining sample, mixed lump, which analyzed 0.47% Fe_2O_3 , was crushed to 840 μm , and a riffled portion ground to pass 420 μm for flotation. Flotation involved first removal of molybdenite using kerosene collector, then acidifying the pulp and floating mica with Armac T collector. The mica tails were dewatered and ground to 95% minus 150 μm , and feldspar floated from quartz using Armaflote 54-67 with hydrofluoric acid to activate the feldspar.

Results : A feldspar concentrate analyzing 18.1% Al_2O_3 and 0.48% Fe_2O_3 , and representing a recovery of 67.2%, was obtained.

Remarks : The concentrated feldspar from the lump was still too high in iron to be suitable as glass-grade feldspar. The hand-picked feldspar crystal could be suitable for amber glass or as glazing spar.

Potential Use : Unsuitable as glass-grade feldspar.

C-83

QUEBEC

Identification	: Que.-1 (Ref. No. 55)
Report - Title	: INVESTIGATION OF IMPURITIES IN BACK MINE FELDSPAR
- Authors	: H.M. Woodroffe and J.E. Reeves
- No. and Date	: <i>Investigation Report</i> 59-106 (1959)
Sample Description	: Two samples of ground feldspar, No. 1 - soda spar and No. 2 - potash spar, each containing small amounts of a finely divided carbonaceous material.
Objective	: To establish a reliable method for determining the amount of carbonaceous material in each sample.
Processing	: Determination of carbonaceous content by a "gas test", which involved adding a slight excess of concentrated hydrochloric acid (in excess of that required to dissolve the estimated carbonaceous material) to 100 g of feldspar mixed with 30 to 40 mL of water. The volume of CO ₂ was measured and thus the carbonaceous content accurately estimated.
Results	: Sample 1 analyzed 0.4% calcite, and sample 2 <0.1%.
Potential Use	: Not applicable.

Identification	: Que.-2 (Ref. No. 56)
Report - Title	: COLOUR-SORTING TESTS ON FELDSPAR FROM BUCKINGHAM
- Author	: R.A. Wyman
- No. and Date	: <i>Mineral Processing Test Report 64-33 (1964)</i>
Sample Description	: Two samples: sample 1, Back Mine Spar, Mine Run; and sample 2, Mine Run Fines, Back Mine North End. Each sample, sized at minus 12.5 plus 1.7 mm, consisted of feldspar, quartz and unidentified discoloured silicates.
Objective	: To separate quartz and discoloured silicates from feldspar.
Processing	: Screening at 6.7 mm to produce separate plus 6.7 mm and minus 6.7 mm fractions for each sample. Each product was passed separately through the laboratory Sortex G3S colour sorter. It was necessary to make more than one pass through the colour sorter before an acceptable grade feldspar product was obtained.
Results	: - The weight recovery of the plus 6.7 mm fraction of sample 1 was 88.8%, and of the minus 6.7 mm fraction, 83.8%. The weight recovery of the plus 6.7 mm fraction of sample 2 was 66%, and of the minus 6.7 mm fraction, 54%. The four products analyzed 0.015% to 0.027% Fe_2O_3 , 17.9% to 19.1% Al_2O_3 , 10.3% to 12.7% K_2O , and 65.7% to 67.8% SiO_2 .
Potential Use	: The low iron oxide content implied suitability for the glass industry.

- Identification : Que.-3 (Ref. No. 57)
- Report - Title : TESTING OF ALTERED FELDSPAR FROM
CHATEAU RICHTER, QUEBEC, FOR ITS
PERTINENT PROPERTIES FOR CERTAIN TYPES OF
FILLERS
- Author : J.S. Ross
- No. and Date : *Mineral Processing Test Report* 60-49 (1960)
- Sample Description : A 68 kg sample of altered feldspar varying in size from
50 mm fragments to very fine material.
- Objective : To produce a product suitable for use as a filler in the
rubber and paper industries.
- Processing : An 8.6 kg sample was dry ground in a pebble mill for 6 h
and screened at 44 μm . The plus 44 μm oversize was
stage wet ground for a further 5 h. The combined minus
44 μm products were then dried, and the sample tested for
various filler properties including light reflectivity, specific
surface area, oil absorption, average and maximum
particle size. A standard filler used for linoleum
applications was also tested.

Results

Property	Test	Linoleum
Light Reflectivity (%)	63	83
Specific Surface Area (cm^2/g)	9627	8318
Oil Absorption (mL/20 g)	6.1	8.5
Average Size (μm)	10	9.5
Maximum Size (μm)	96	61

The light reflectance is somewhat lower than for the filler,
but for linoleum applications the reflectivity is not critical.

- Potential Use : Possibly suitable as a filler for certain applications
including linoleum.

- Identification : Que.-4 (Ref. No. 58)
- Report - Title : INVESTIGATION INTO SOME POSSIBLE CERAMIC
USES OF A KAOLINIZED FELDSPAR FROM
CHATEAU RICHER
- Author : K.E. Bell
- No. and Date : *Investigation Report* 60-113 (1960)
- Sample Description : A sample of lumps of a light-coloured granular kaolinized
feldspar showing evidence of iron staining and inclusions
of mica. X-ray diffractometer analysis indicated about
65% plagioclase feldspar, 20-24% kaolinized clay and
minor microcline, anatase, ilmenite and chlorite.
- Objective : Evaluation for ceramic whiteware and, subsequently, in
structural clay products.
- Processing : Wet grinding to 98.1% minus 75 μ m followed by washing
of the plus 75 μ m oversize. The washed screen undersize
was passed through a Frantz Ferrofilter to remove
magnetic material. The non-magnetic fraction was
filtered, dried and ground to micron size in a Mikro
Sample mill.

Whiteware evaluation consisted of mixing batches with water, granulating for pressing at 2000 p.s.i., drying at 110°C and bisquing at 1110°C in a globar kiln. The bisqued pieces were glazed on one side and refired at 1165°C. The properties tested for, included colour, warpage, glaze fit and crazing, shrinkage, absorption and moisture expansion.

The evaluation as a minor constituent in structural clay involved drying and grinding to pass 1.2 mm and batches were mixed with various proportions of a standard stoneware clay. The plastic qualities of each batch, and the optimum amount of water for extrusion were determined from tests using a Brabender Plastograph. Test pieces were fired at various temperatures and the shrinkage noted. Fired pieces were tested for moduli of rupture, and water absorption.

Que.-4 (Ref. No. 58) Cont'd

Results

: The evaluation for whiteware use was reasonably successful with respect to colour, moisture expansion and crazing characteristics when using 20% kaolinized feldspar. The evaluation as a constituent in structural clay was not satisfactory, but when added in amounts up to 40% kaolinized feldspar to a buff-firing clay, it improved the general plastic properties and fired properties with only a minor decrease in strength.

Potential Use

: Suitable for incorporation into a wall-tile body in whiteware applications.

Identification	: Que.-5 (Ref. No. 59)
Report - Title	: USE OF FELDSPATHIC TAILINGS FROM CHATEAU RICHER AS A CONSTITUENT OF FACING BRICKS
- Author	: K.E. Bell
- No. and Date	: <i>Mineral Processing Test Report</i> MPT 61-102 (1961)
Sample Description	: A sample of coarse feldspathic tailings remaining after removal of kaolin, and a sample of pulverized tailings, ground to 44 μ m.
Objective	: Evaluation as a constituent of bricks.
Processing	: Stoneware evaluation was essentially similar to that described in the previous investigation. The plastic properties of several mixtures of feldspathic tailings with a standard stoneware clay were investigated using a Brabender Plastograph. The pulverized tailings alone and in combination with coarse tailings were also evaluated using a Brabender Plastograph. Test bars of various mixtures were formed by extrusion, dry pressing, and several were fired in an electric kiln. Dry and fired properties were determined.
Results	: Testwork indicated that there was a noticeable improvement in saturation coefficient when using coarse-size material which was probably due to the removal of the refractory kaolin fraction. Absorptions were somewhat lower at equivalent temperatures probably due, in part, to the same cause. Strengths reported were generally lower than in the previous investigation which were due in part to less water being used for extrusion and to the removal of fine-particle size kaolin. The evaluation of the pulverized material indicated that fine particle size does not of itself contribute sufficiently to plasticity or reduced refractoriness to merit substitution of this material for the greater part of the clay portion. The same mixtures as recommended in the previous investigation appear to be suitable for the production of first-class brick.
Potential Use	: Suitable for the manufacture of facing bricks in stoneware applications.

Identification	: Que.-6 (Ref. No. 60)
Report - Title	: SOME POSSIBLE CERAMIC USES OF FELDSPAR TAILINGS FROM CHATEAU RICHER
- Author	: M. Palfreyman
- No. and Date	: <i>Mineral Processing Test Report</i> MPT 73-9 (1973)
Sample Description	: A sample of feldspathic tailings composed mainly of plagioclase feldspar with 20 to 24% kaolin, off-white in colour, with no obvious foreign inclusions.
Objective	: Evaluation for use in either wall tile or stoneware applications.
Processing	: Crushing and grinding to pass 75 μm , washing to remove kaolin and magnetic separation in a Jones wet high- intensity separator. Wall tile evaluation involved preparing several extruded bars using the feldspar mixed with lime, ball clay and water. The bars were air dried, oven dried, and finally fired in an electric furnace. Stoneware evaluation involved preparing several extruded bars using the feldspar mixed with stoneware clay, ball clay and water. The bars were dried and fired in the same manner as the wall tile bodies, and wet to fired shrinkage and water absorption values were determined.
Results	: The wall tile evaluation determined that for temperatures < 1200°C, control would be more flexible than at temperatures > 1200°C, and it may be possible to produce a satisfactory wall tile body. Stoneware evaluation indicated that little change took place between 1200 and 1250°C, which would allow more flexibility in kiln control. A good quality vitrified floor tile could, therefore, be produced from the feldspar mixture.
Potential Use	: Suitable for employing in either a wall-tile body or a vitrified floor tile body.

C-90

Identification : Que.-7 (Ref. No. 61)

Report - Title : REDUCTION OF DENTAL-GRADE FELDSPAR FROM LUMP TO POWDER

- Author : R.A. Wyman

- No. and Date : *Mineral Processing Test Report 73-4 (1973)*

Sample Description : A 14 kg sample of dental-grade feldspar obtained from a deposit near Thurso, Quebec

Objective : To develop a suitable grinding procedure for the production of minus 75 μm dental-grade feldspar.

Processing : Hand sorting into "stained" and "non-stained" portions, designated as samples A and B, respectively. Sample A was screened to produce a plus 25 mm, and a minus 25 mm fraction. The minus 25 mm fraction was crushed to 9.5 mm and stage-ground to pass 600 μm in an Abbé mill. Sample B was similarly treated to produce minus 600 μm material.

Further grinding to produce about 50% minus 75 μm , for each sample, was also conducted in an Abbé mill. Brightness determinations were made on each ground product.

Results : Brightness value of ground sample A was 100% and for sample B, 98.2%.

Remarks : The successful production of minus 75 μm material by self-grinding suggests that for a production unit, a grinding mill lined with fused alumina in closed circuit with an air classifier, would be sufficient.

Potential Use : Suitable for dental-grade use.

C-91

Identification : Que.-8 (Ref. No. 62)

Report - Title : PRODUCTION OF MINUS TWO HUNDRED MESH
FELDSPAR FOR DENTAL USE

- Author : R.A. Wyman and J.T. Murphy

- No. and Date : *Mineral Processing Test Report* 74-5 (1974)

Sample Description : A 227 kg sample of quarry feldspar from Thurso.

Objective : To establish grinding parameters for the production of
22.5 to 45 kg/day of minus 75 μ m product.

Processing : Grinding trials were conducted using a 0.6 by 0.9 m
Patterson ceramic-lined mill, and sizing using a 0.6 by
0.9 m NoVo vibrating screen fitted with a 75 μ m screen.
The grinding procedure involved grinding 80 kg of feed
for 3 h, hand screening the plus 4.8 mm, and passing the
minus 4.8 mm over the vibrating screen. The second
grinding trial involved grinding the plus 4.8 mm from trial
No. 1 together with 11.4 kg of minus 4.8 mm plus 75 μ m
from trial No. 1 and 27.2 kg of new feed for a total
charge of 91 kg. This procedure was repeated for an
additional three grinding trial runs.

Results : The grinding results indicated that a larger capacity
grinding mill (0.9 by 1.8 m) would be sufficient to
produce 22.5 to 45 kg/day of minus 75 μ m product.

Potential Use : Suitable for dental-grade use.

- Identification : Que.-9 (Ref. No. 63)
- Report - Title : FELDSPAR UPGRADING FOR MAGDALEN SILICA
INCORPORATED: PROGRESS REPORT NO. 1
- Author : G.I. Mathieu
- No. and Date : *Division Report* 82-7 (CR) (1982)
- Sample Description : A 40 kg sample of partially upgraded feldspar remaining after removal of silica sand. The mineralogical composition was 55 % orthoclase, 15 % albite and 30 % quartz, with minor iron oxide and ferro-magnesian minerals analyzing 0.61 % Fe_2O_3 .
- Objective : To produce a high-grade feldspar product suitable for the glass and ceramic industries.
- Processing : Various processing combinations were assessed: a differential iron flotation stage before quartz-feldspar separation; and wet and dry magnetic separation before quartz-feldspar separation. The quartz-feldspar separation was achieved by using the non-hydrofluoric acid flotation method on minus 250 μm material.
- Results : The iron flotation was not very successful, nor were the magnetic separation trials because of residual flotation reagents remaining (from previous silica sand testwork) on the mineral surfaces. The quartz-feldspar separation was similarly hampered by residual reagents, so that separation was best by first acid leaching, alkali scrubbing, and desliming before flotation.
- The best application of magnetic separation for glass-grade was after flotation, and for ceramic-grade after the final grinding to 75 μm .
- A porcelain feldspar analyzing 0.049 % Fe_2O_3 , a ceramic feldspar analyzing 0.076 % Fe_2O_3 , and a glass-grade feldspar analyzing 0.11 % Fe_2O_3 were obtained.
- Potential Use : Possibly suitable for glass and ceramic-grade use.

BRITISH COLUMBIA

- Identification : B.C.-1 (Ref. No. 64)
- Report - Title : DRY WORKING OF A SAMPLE OF GRANITE FROM ARMSTRONG
- Author : R.A. Wyman
- No. and Date : *Investigation Report 58-36 (1958)*
- Sample Description : A 90 kg sample of granite pegmatite consisting of white albite, quartz, mica and feldspar, with minor amounts of red garnets.
- Objective : To produce separate quartz, muscovite and feldspar products.
- Processing : Lumps of pure quartz were first removed by hand cobbing. The remaining sample was jaw and rolls crushed to 1.7 mm. During this operation, plus 3.4 mm and plus 1.7 mm mica fractions were obtained. The minus 1.7 mm was further screened to obtain minus 1.7 plus 1.2 mm, minus 1.2 plus 850 μm , minus 850 plus 600 μm , minus 600 plus 420 μm , and minus 420 μm fractions. Each fraction (except the minus 420 μm) was air tabled to produce mica, feldspar, and mixed quartz-feldspar products.
- Results : High-grade feldspar products, accounting for 43% weight recovery, were obtained in the minus 1.7 mm through to plus 420 μm fractions.
- Potential Use : Not determined.

Identification	: B.C.-2 (Ref. No. 65)
Report - Title	: A PRELIMINARY EVALUATION OF A FELDSPAR SAMPLE FROM BARRIÈRE
- Authors	: P.R.A. Andrews and P.J.H. Prud'homme
- No. and Date	: <i>Division Report</i> 90-19 (CR) (1990)
Sample Description	: A 2 kg sample of high-grade drill core sample analyzing 97% potash feldspar; the impurities included biotite, chlorite, garnet, magnetite, hematite, pyrite, sericite and carbonaceous material.
Objective	: To reduce the iron oxide level to $<0.23\%$ Fe_2O_3 and, if possible, to $<0.1\%$ Fe_2O_3 .
Processing	: Crushing and stage, wet-grinding to pass $210\ \mu\text{m}$. The ground ore was scrubbed at a high pH using sodium hydroxide, and then deslimed at $53\ \mu\text{m}$ to remove fine mica. The remaining micaceous material and some of the iron oxides were removed in a two-stage flotation step. The remaining iron oxides were removed from the concentrated feldspar by high-intensity, wet magnetic separation.
Results	: A feldspar product analyzing 0.11% Fe_2O_3 , 0.01% TiO_2 and $>99\%$ feldspar was obtained.
Potential Use	: Possibly suitable for certain applications in the glass industry.

APPENDIX 4

SUMMARIES OF FELDSPAR STUDIES BY OTHER ORGANIZATIONS



MANITOBA

- Identification : Man.-1 (Ref. No. 66)
- Report - Title : MANITOBA FELDSPAR PRODUCT EVALUATION
AND MARKET STUDY
- Author : G.H.K. Pearse
- No. and Date : *Canada-Manitoba MDA Report O1SR.23230-5-0160*
(1986)
- Sample Description : A 90 kg sample of rubidium feldspar pre-concentrated by
heavy-liquid separation, which analyzed 1.32% Rb₂O.
- Objective : To determine suitability for glass and ceramic use.
- Processing : The sample was ground and sized into three products:
minus 420 μ m, minus 75 μ m, and minus 44 μ m. Glass-
melt studies of a soda-lime and a lead glass were prepared
using the rubidium feldspar product. Each melt was
evaluated to determine softening, annealing and strain
points; coefficient of expansion; specific gravity; liquidus
temperature; and electrical resistivity.
- Results :

Property	Soda-Lime Glass		012 Type Lead Glass	
	Typical Values	Test Glass	Typical Values	Test Glass
Softening Point (°C)	724	724	630	642
Anneal Point (°C)	550	552	435	450
Strain Point (°C)	508	507	395	427
Expansion ($\times 10^{-7}/^{\circ}\text{C}$)	89.8	88.7	89.5	90.1
Density (g/mL)	2.50	2.50	3.05	3.04
Liquidus (°C)	980(avg)	975(avg)	760(avg)	none
Electrical Resistivity (250°C)	6.6	7.0	10.1	9.9
(350°C)	5.3	5.6	8.0	7.9

- Potential Use : The low iron content and presence of rubidia indicate a
superior performance as an ingredient in ceramics and
specialty glass products.

D-98

Identification : Man.-2 (Ref. No. 67)

Report - Title : UPGRADING OF FELDSPAR FROM TANCO,
BERNIC LAKE

- Authors : R.O. Burt and J. Flemming

- No. and Date : *Canada-Manitoba MDA Report* 03SQ.23440-5-9246 (1987)

Sample Description : A sample of Triflo heavy media separator rejects
analyzing about 75 % feldspar.

Objective : To produce filler-grade feldspar.

Processing : Grinding to about 300 μm followed by flotation. Selected
concentrates were further ground to 37 μm and brightness
value trials conducted.

Results : A feldspar concentrate analyzing about 85 % feldspar and
representing a recovery of 64.25 % was obtained.
Brightness trials indicated an almost pure white product
for ground concentrates.

Potential Use : Suitable as filler-grade feldspar.